

Phenytoin

Phenytoin, which was discovered in 1938, was the first anti-seizure medication and is still being used to control seizures.

McCuiston, L., Vuljoin-DiMaggio, K., Winton, M, & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 227-305. Elsevier.

Mechanism of Action

Phenytoin improves evidence of seizures by interfering with sodium channels in the brain, resulting in a reduction of sustained high-frequency neuronal discharges.

Indications for Use

Phenytoin is indicated for the treatment of tonic-clonic (grand mal) and psychomotor (temporal lobe) seizures and for the prevention and treatment of seizures occurring during or following neurosurgery.

Nursing Considerations Across the Lifespan

Phenytoin should not be administered to pregnant women because it will cause harm to the fetus. When given intravenously, there is a Black Box Warning that the rate of administration should not exceed 50 mg per minute in adults and 1 to 3 mg/kg/min (or 50 mg per minute, whichever is slower) in pediatric patients because of the risk of severe hypotension and cardiac arrhythmias. Careful cardiac monitoring is needed during and after administering intravenous phenytoin.

Phenytoin has a narrow therapeutic drug level, usually between 10-20 mcg/ml, so serum drug monitoring is required. Serum levels of phenytoin sustained above the therapeutic range may produce confusional states referred to as delirium, psychosis, or encephalopathy. Accordingly, at the first sign of acute toxicity, serum levels should be immediately checked.

Abrupt discontinuation can cause status epilepticus, so in the event of an allergic or hypersensitivity reaction, rapid substitution of alternative therapy may be necessary.

Use with caution in patients with renal or hepatic impairment. Elderly patients may require dosage adjustment.

There are many potential drug interactions with phenytoin. Read drug label information before administering. Phenytoin is extensively bound to plasma proteins and is prone to competitive displacement. Phenytoin is metabolized by hepatic cytochrome P450 enzymes, so it is susceptible to inhibitory drug interactions, which may produce significant increases in circulating phenytoin concentrations and enhance the risk of drug toxicity.

Adverse/Side Effects

Serious and sometimes fatal dermatologic reactions, including toxic epidermal necrolysis (TEN) and Stevens-Johnson syndrome (SJS), have been reported with phenytoin treatment. The onset of symptoms is usually within 28 days, but can occur later. Phenytoin should be discontinued at the first sign of a rash.

Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS) has been reported in patients taking antiepileptic drugs, including phenytoin. Some of these events have been fatal or life threatening. DRESS typically presents with fever, rash, lymphadenopathy, and/or facial swelling, in association with other organ system involvement. These findings should be immediately reported to the provider. Acute hepatotoxicity has been reported with phenytoin. These events may be part of the spectrum of DRESS or may occur in isolation.

Hematopoietic complications, some fatal, have occasionally been reported in association with administration of phenytoin. These have included thrombocytopenia, leukopenia, granulocytopenia, agranulocytosis, and pancytopenia with or without bone marrow suppression.

The most common adverse reactions encountered with phenytoin therapy are nervous system reactions and are usually dose-related. Reactions include nystagmus, ataxia, slurred speech, decreased coordination, somnolence, and mental confusion.

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Patient Teaching & Education

Patients should be advised to take medications as directed and that doses should be evenly spaced throughout the day. It may take several weeks to obtain the desired medication effect. Abrupt withdrawal of medication may cause status epilepticus. Patients should avoid alcohol and other CNS depressants while taking anticonvulsant drug therapy. Additionally, diabetic patients should monitor their blood glucose levels carefully.

Now let's take a closer look at the medication grid for phenytoin in Table 8.10a.

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Table 8.10a Phenytoin Medication Grid

Class/Subclass	Prototype/ Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Anticonvulsant phenytoin		Careful cardiac monitoring is needed during and after administering intravenous phenytoin		Cardiovascular risk associated with rapid IV infusion
		For IV infusions, an in-line filter (0.22 to 0.55 microns) should be used.		Discontinue and notify the provider if a rash occurs
		Cannot be given with D5W due to precipitation and no faster than 50 mg/minute in adults	Decrease or prevent seizure activity	Notify the provider immediately if fever, rash, lymphadenopathy, and/or facial swelling occur
		Monitor serum drug levels		
		Contraindicated with patient with heart block		
		Use cautiously in patients with hepatic or renal impairment		Cardiovascular: arrhythmia and hypotension

CNS: Nystagmus, ataxia, slurred speech, decreased coordination, somnolence, and mental confusion

Taper dose; do not stop abruptly

GI: Constipation, gingival hyperplasia, and hepatotoxicity

Hematology:
Thrombocytopenia, pancytopenia, and agranulocytosis

Levetiracetam

Levetiracetam is indicated as adjunctive therapy in the treatment of partial onset seizures in patients 12 years of age and older with epilepsy. It is generally well tolerated.

Mechanism of Action

The exact mechanism of action is unknown. This medication may interfere with sodium, calcium, potassium, or GABA transmission.

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Indications for Use

Levetiracetam is used for partial onset seizures in patients with epilepsy.

Nursing Considerations Across the Lifespan

Plasma levels can gradually decrease during pregnancy and should be monitored closely. Safety and effectiveness in pediatric patients 12 years of age and older have been established.

Levetiracetam immediate release and solution can be used in patients as young as 1 month.

Levetiracetam should not be stopped abruptly or withdrawal seizures may occur. Use with caution in patients with renal impairment.

Adverse/Side Effects

Behavioral abnormalities including psychotic symptoms, suicidal ideation, irritability, and aggressive behavior have been observed; monitor patients for psychiatric signs and symptoms.

The most common adverse reactions are somnolence and irritability. Advise patients not to drive or operate machinery until they have gained sufficient experience on levetiracetam.

This drug can cause anaphylaxis or angioedema after the first dose or at any time during treatment. Serious dermatological reactions, including Stevens-Johnson syndrome (SJS) and toxic epidermal necrolysis (TEN), have been reported, as well as coordination difficulties and hematologic abnormalities.

Patient Teaching & Education

Medications should be taken as directed and may cause increased dizziness and somnolence. Patients, family, and caregivers should also monitor carefully for suicidality during medication therapy.

Now let's take a closer look at the medication grid for levetiracetam in Table 8.10b.

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Table 8.10b Levetiracetam Medication Grid

Class/Subclass	Prototype/ Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Anticonvulsant	levetiracetam	Taper dose; do not stop abruptly or seizures may occur	Decrease seizure activity	Behavioral/mood changes (psychotic symptoms, suicidal ideation, irritability, and aggressive behavior)
				Anaphylaxis or angioedema
		Monitor plasma levels for pregnant women		Somnolence, fatigue, and irritability
				Serious skin conditions
		Use cautiously if renal impairment		Coordination difficulties
				Hematopoietic abnormalities

Gabapentin

Gabapentin is indicated as an adjunct treatment for partial seizures, but is most commonly used to treat neuropathic pain.

Lilley, L., Collins, S., & Snyder, J. (2020). *Pharmacology and the Nursing Process*. pp. 246-272. Elsevier.

Mechanism of Action

The exact mechanism of action is unknown. It is structurally similar to GABA, but does not act on GABA receptors or influence GABA.

Indications for Use

Gabapentin is used for partial seizures and neuropathic pain.

Nursing Considerations Across the Lifespan

This drug can cause harm to the fetus of pregnant women.

Gabapentin use in pediatric patients with epilepsy 3 to 12 years of age is associated with the occurrence of central nervous system related adverse events. The most significant of these can be classified into the following categories: 1) emotional lability (primarily behavioral problems); 2) hostility, including aggressive behaviors; 3) thought disorder, including concentration problems and change in school performance; and 4) hyperkinesia (primarily restlessness and hyperactivity).

In elderly patients, peripheral edema and ataxia tended to increase in incidence with age. Fall precautions should be considered.

Antiepileptic drugs should not be abruptly discontinued because of the possibility of increasing seizure frequency.

Adverse/Side Effects

Antiepileptic drugs, including gabapentin, increase the risk of suicidal thoughts or behavior in patients taking these drugs for any indication. Patients should be monitored for the emergence or worsening of depression, suicidal thoughts or behavior, and/or any unusual changes in mood or behavior.

Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS), also known as multiorgan hypersensitivity, has been reported in patients taking antiepileptic drugs, including gabapentin. Some of these events have been fatal or life threatening. DRESS typically, although not exclusively, presents with fever, rash, and/or lymphadenopathy, in association with other organ system involvement. If these symptoms occur, they should be immediately reported to the provider.

Gabapentin may cause dizziness, somnolence, and other symptoms and signs of CNS depression. Patients should be advised neither to drive a car nor to operate other complex machinery until they have gained sufficient experience on gabapentin to gauge whether or not it affects their mental and/or motor performance adversely.

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Patient Teaching & Education

Patients receiving gabapentin therapy should take medication as directed and be careful to not exceed dosage recommendations. Patients should not take gabapentin within 2 hours of antacid medications. Additionally, gabapentin may cause increased drowsiness and dizziness. Patients, family, and caregivers should also monitor for suicidality.

Now let's take a closer look at the medication grid for gabapentin in Table 8.10c.

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Table 8.10c Gabapentin Medication Grid

Class/Subclass	Prototype/ Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Anticonvulsant	gabapentin	Administer first dose at bedtime to	Decreased	Increased suicidal

decrease dizziness and drowsiness		ideation
Monitor for worsening depression, suicidal thoughts or behavior, and/or any unusual changes in mood or behavior	neuropathic pain or seizures	Immediately report fever, rash, and/or lymphadenopathy
Taper dose; do not stop abruptly		CNS depression: dizziness, somnolence, and ataxia

Critical Thinking Activity 8.10

Image of lightbulb in a circle

A 70-year-patient in a long-term care center has diabetes and has been prescribed gabapentin for neuropathic pain.

1. The patient states, “I have never had a seizure. Why has the doctor prescribed an antiseizure medication for me?” What is the nurse’s best response?
2. The nurse plans to implement additional fall precautions for this patient. Why are additional fall precautions needed?
3. What potential adverse effects should the nurse plan to monitor? What adverse effects would require immediate notification of the provider?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

8.11 Antiparkinson Medications

Open Resources for Nursing (Open RN)

Parkinson’s disease is believed to be related to an imbalance of dopamine and acetylcholine and a deficiency of dopamine in certain areas of the brain, so drug therapies are aimed at increasing levels of dopamine and/or antagonizing the effects of acetylcholine. Drug therapy does not cure the disease, but is

used to slow the progression of symptoms. Common medications used to treat Parkinson's disease are carbidopa/levodopa, selegiline, and amantadine.

Lilley, L., Collins, S., & Snyder, J. (2020). *Pharmacology and the Nursing Process*. pp. 246-272. Elsevier.

Carbidopa/Levodopa

Carbidopa/levodopa is the most common drug used to treat Parkinson's disease and is usually started as soon as the patient becomes functionally impaired.

Mechanism of Action

Administration of dopamine is ineffective in the treatment of Parkinson's disease because it does not cross the **blood-brain barrier**, but levodopa, the metabolic precursor of dopamine, does cross the blood-brain barrier and presumably is converted to dopamine in the brain. Carbidopa is combined with levodopa to help stop the breakdown of levodopa before it is able to cross the blood-brain barrier. Additionally, the incidence of levodopa-induced nausea and vomiting is less when it is combined with carbidopa.

Indications for Use

Carbidopa/levodopa is indicated for Parkinson's disease. It is also used to treat restless leg syndrome.

Nursing Considerations Across the Lifespan

Carbidopa/Levodopa is recommended for use in patients older than age 18. It can take several weeks to see positive effects and this should be explained to patients and their caregivers.

The drug is contraindicated for use with MAOIs. All patients should be observed carefully for the development of depression with concomitant suicidal tendencies.

Patients taking carbidopa and levodopa have reported suddenly falling asleep without prior warning of sleepiness while engaged in activities of daily living (including operation of motor vehicles). Patients should be advised to exercise caution while driving or operating machines during treatment with carbidopa and levodopa.

Sporadic cases of symptoms resembling neuroleptic malignant syndrome (NMS) have been reported in association with dose reductions or withdrawal of certain antiparkinsonian agents. Therefore, patients should be observed carefully when the dosage of levodopa is reduced abruptly or discontinued.

Periodic evaluations of hepatic, hematopoietic, cardiovascular, and renal functions are recommended during extended therapy. The most common adverse effect of carbidopa/levodopa is dyskinesia, which may require dosage reduction.

Patients should be instructed to plan their meal times around medication times to improve the ability to use their utensils and to avoid diets high in protein due to decreased absorption of the medication.

Adverse/Side Effects

Hallucinations and psychotic-like behavior have been reported with dopaminergic medications. Patients

taking dopaminergic medications may experience intense gambling urges, increased sexual urges, intense urges to spend money, binge eating, and/or other intense urges, and the inability to control these urges. These urges stopped when the dosage was decreased or the medication discontinued.

A higher risk for melanoma has been reported. Occasionally, dark red, brown, or black color may appear in saliva, urine, or sweat after ingestion of carbidopa and levodopa. Although the color appears to be clinically insignificant, garments may become discolored.

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McCuiston, L., Vuljoin-DiMaggio, K., Winton, M., & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 227-305. Elsevier.

Lilley, L., Collins, S., & Snyder, J. (2020). *Pharmacology and the Nursing Process*. pp. 246-272. Elsevier.

Patient Teaching & Education

Patients should take their medications at regular intervals as directed. If gastric irritation is experienced, patients may eat food shortly after taking medications but high-protein foods may impair drug action. Medications may cause increased drowsiness, dizziness, and orthostatic changes. Patients should carefully assess their skin to monitor for new lesions and any abnormality should be reported to the healthcare provider.

Now let's take a closer look at the medication grid for carbidopa-levodopa in Table 8.11.

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Table 8.11a Carbidopa-Levodopa Medication Grid

Class-subclass	Prototype/Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Antiparkinson agent	carbidopa/levodopa	Avoid high-protein diets due to decreased absorption Monitor for sudden somnolence and increased depression Contraindicated with MAOIs Periodically	Slow progression of symptoms of Parkinson's disease (tremors, rigidity, and mobility issues)	Depression, suicidal ideation, hallucinations, and intense urges with inability to control them Somnolence and fatigue NMS symptoms with dose reductions or when discontinued Dyskinesia Discolored body fluids Hypomobility with long-term use

		monitor hepatic, renal, and hematopoietic functions		
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Selegiline

Selegiline is often used conjunction with carbidopa-levodopa when patients demonstrate a deteriorating response to this treatment. It is helpful to control symptom fluctuations.

Lilley, L., Collins, S., & Snyder, J. (2020). *Pharmacology and the Nursing Process*. pp. 246-272. Elsevier.

Mechanism of Action

Selegiline inhibits MAO-B, blocking the breakdown of dopamine.

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Indications for Use

Selegiline capsules are indicated as an adjunct in the management of Parkinsonian patients being treated with levodopa/carbidopa who exhibit deterioration in the quality of their response to this therapy. There is no evidence from controlled studies that selegiline has any beneficial effect in the absence of concurrent levodopa therapy.

Nursing Considerations Across the Lifespan

Large doses of selegiline may inhibit MAO-A that promotes metabolism of tyramine in the GI tract, which can cause a hypertensive crisis.

Adverse/Side Effects

Side effects are dose dependent, with larger doses posing a hypertensive crisis risk if there is consumption of food or beverages with tyramine.

Patient Teaching & Education

Patients should be advised to avoid foods high in tyramine. Additionally, medications may cause increased drowsiness, dizziness, and orthostatic changes. If patients experience abnormal behaviors such as hallucination, sexual urges, gambling, etc., this should be reported promptly to the healthcare provider.

Now let's take a closer look at the medication grid for selegiline in Table 8.11b.

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Table 8.11b Selegiline Medication Grid

Class/ Subclass	Prototype/ Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Antiparkinson agent, MAO Type B Inhibitor	selegiline	Avoid food with tyramine if on a large dose (above 10mg/day)	Minimize progression of Parkinson's disease symptoms	Higher doses increase risk for hypertensive crisis

Amantadine

Amantadine is used in early stages of Parkinson's disease but can be effective in moderate or advanced stages in reducing tremor and muscle rigidity.

Lilley, L., Collins, S., & Snyder, J. (2020). *Pharmacology and the Nursing Process*. pp. 246-272. Elsevier.

Mechanism of Action

The exact mechanism of action is unknown. Amantadine is an antiviral drug that acts on dopamine receptors.

McCustion, L., Vuljoin-DiMaggio, K., Winton, M, & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 227-305. Elsevier.

Indications for Use

Amantadine is used for Parkinson's disease, medication-induced extrapyramidal symptoms, and influenza A.

Nursing Considerations Across the Lifespan

Use cautiously with renal impairment. This drug may cause suicidal ideation and should not be stopped abruptly or can cause Parkinsonian crisis. Neuroleptic Malignant Syndrome (NMS) has been reported in association with dose reduction or withdrawal of amantadine therapy.

Adverse/Side Effects

Suicide ideation, congestive heart failure, and peripheral edema can occur. This drug can cause intense gambling urges, increased sexual urges, intense urges to spend money uncontrollably, and other intense urges with an inability to control them. There is an increased risk of melanoma.

Adverse reactions reported most frequently are nausea, dizziness (lightheadedness), and insomnia. This drug can also cause anticholinergic side effects, impaired thinking, and orthostatic hypotension.

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Patient Teaching & Education

Patients should take medications as directed and ensure they do not skip or double doses. Medications

may cause drowsiness, dizziness, and orthostatic blood pressure changes. Patients should avoid using this medication with OTC cold medications or alcoholic beverages. If patients, family, or caregivers note worsening depression or suicidality, this should be reported immediately to the healthcare provider.

Now let's take a closer look at the medication grid for amantadine in Table 8.11c.

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Table 8.11c Amantadine Medication Grid

Class	Prototype/ Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Anti-Parkinson Agent, Antiviral	amantadine	Monitor renal function Monitor mental state Assess blood pressure	Improve Parkinson's disease symptoms	Increased suicidal ideation and urges Congestive heart failure and peripheral edema Neuromalignant syndrome (NMS) when dosage decreased Orthostatic hypotension Nausea, dizziness, and insomnia Anticholinergic side effects

Critical Thinking Activity 8.11

Image of lightbulb in a circle

A 76-year-old patient in a long-term care center has developed a shuffling gait with a stooped posture, along with a hand tremor at rest. The nurse practitioner prescribed carbidopa/levodopa.

1. The nurse knows that Parkinson's disease is related to dopamine, but dopamine can't cross the blood-brain barrier. How will carbidopa/levodopa assist with dopamine levels?
2. The patient states, "I am looking forward to spending next weekend with my grandson. He even said he would let me drive his new Mustang!" What teaching should the nurse provide the patient and his

grandson (with the patient's permission) regarding the new medication and his weekend plans?

3. The nurse reads that the most common side effect of carbidopa-levodopa is dyskinesia. What is dyskinesia? If it occurs, what is the likely treatment?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

8.12 Module Learning Activities

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Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=1824#h5p-26>

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=1824#h5p-27>

VIII: Glossary

Open Resources for Nursing (Open RN)

Action potential: A change in voltage of a cell membrane in response to a stimulus that results in transmission of an electrical signal; unique to neurons and muscle fibers.

Acute dystonia: Painful muscle spasms.

Affective mood disorders: Mental illness such as major depression.

Akathisia: Distressing motor restlessness.

Blood-brain barrier (BBB): A physiological barrier between the circulatory system and the central nervous system that establishes a privileged blood supply, restricting the flow of substances into the CNS.

Bradykinesia: Slowness in initiation and execution of voluntary movements.

Central nervous system (CNS): Anatomical division of the nervous system located within the cranial and vertebral cavities, namely the brain and spinal cord.

Chemical synapse: Connection between two neurons, or between a neuron and its target, where a neurotransmitter diffuses across a very short distance.

Drug Reaction with Eosinophilia and Systemic Symptoms (DRESS): A condition reported in patients taking antiepileptic drugs. Some of these events have been fatal or life threatening. DRESS typically presents with fever, rash, lymphadenopathy, and/or facial swelling.

Dystonia: Inappropriate and continuous muscle contraction.

Electrical synapse: Connection between two neurons, or any two electrically active cells, where ions flow directly through channels spanning their adjacent cell membranes.

Extrapyramidal symptoms: Involuntary motor symptoms similar to those associated with Parkinson's disease. Includes symptoms such as akathisia (distressing motor restlessness) and acute dystonia (painful muscle spasms). Often treated with anticholinergic medications such as benztropine and trihexyphenidyl.

Gait disturbance: An abnormal way of walking, such as shuffling feet.

Hypertensive crisis: Severe hypertension (blood pressure greater than 180/120 mm Hg) with evidence of organ dysfunction. Symptoms may include occipital headache (which may radiate frontally), palpitations, neck stiffness or soreness, nausea or vomiting, sweating, dilated pupils, photophobia, shortness of breath, or confusion. Either tachycardia or bradycardia may be present and may be associated with constricting chest pain. Seizures may also occur. Intracranial bleeding, sometimes fatal, has been reported in association with the increase in blood pressure.

Mania: Periods of extreme highs in bipolar disorder. Manic episodes may include these symptoms: rapid speech, hyperactivity, reduced need for sleep, flight of ideas, grandiosity, poor judgement, aggression/hostility, risky sexual behavior, neglected basic self-care, or decreased impulse control.

Nerve: Cord-like bundle of axons located in the peripheral nervous system that transmits sensory input and response output to and from the central nervous system.

Neuroleptic malignant syndrome (NMS): Potentially life-threatening adverse effect that includes high fever, unstable blood pressure, and myoglobinemia.

Neuron(s): Neural tissue cell that is primarily responsible for generating and propagating electrical signals into, within, and out of the nervous system.

Neurotransmitter: Chemical signal that is released from the synaptic end bulb of a neuron to cause a change in the target cell.

Ophthalmoplegia: Weakness in eye muscles.

Orthostatic hypotension: A significant change in blood pressure from lying to sitting to standing.

Peripheral nervous system (PNS): An anatomical division of the nervous system that is largely outside the cranial and vertebral cavities, namely all parts except the brain and spinal cord.

Postural instability: Abnormal fixation of posture (stoop when standing), problems with equilibrium, and righting reflex.

Rigidity: Increased muscle tone and increase resistance to movement. As severity increases, there may be cogwheel rigidity.

Serotonin syndrome: May occur when taking serotonin medications. Includes mental status changes (e.g., agitation, hallucinations, coma), autonomic instability (e.g., tachycardia, labile blood pressure, hyperthermia), neuromuscular aberrations (e.g., hyperreflexia, incoordination) and/or gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea). Serotonin syndrome, in its most severe form, can resemble neuroleptic malignant syndrome, which includes hyperthermia, muscle rigidity, autonomic instability with possible rapid fluctuation of vital signs, and mental status changes.

Status epilepticus: A state of repeated or continuous seizures.

Tardive dyskinesia: Involuntary contraction of the oral and facial muscles (such as tongue thrusting) and wavelike movements of the extremities.

Thalamus: The region of the central nervous system that acts as a relay for sensory pathways.

Threshold: The membrane voltage at which an action potential is initiated.

Tremor: Usually tremor at rest; when person sits, the arms shake, but tremor stops when person attempts to grab something.

IX

Endocrine

9.1 Endocrine Introduction

Open Resources for Nursing (Open RN)

Learning Objectives

- Cite the classifications and actions of endocrine system drugs
- Give examples of when, how, and to whom endocrine system drugs may be administered
- Identify the side effects and special considerations associated with endocrine system drug therapy
- Identify the considerations and implications of using endocrine system medications across the lifespan
- Apply evidence-based concepts when using the nursing process
- Identify indications, side effects, and potential drug interactions associated with the use of herbal supplements
- Identify and interpret related laboratory tests

Have you ever wondered how your body controls functions such as digestion, metabolism, and the stress response? The endocrine system is always working behind the scenes, regulating various organs by releasing hormones and using feedback loops. This chapter will discuss medications that affect three of

the major endocrine glands: the adrenal glands, the pancreas, and the thyroid. But before we get started with discussing medications, let's review some key endocrine system concepts to understand the mechanism of action of endocrine medications.

9.2 Endocrine System Basics

Open Resources for Nursing (Open RN)

You may never have thought of it this way, but when you send a text message to two friends to meet you at a restaurant at six, you're sending digital signals that you hope will affect their behavior—even though they are some distance away. Similarly, certain cells send chemical signals to other cells in the body that influence their behavior. This long-distance intercellular communication, coordination, and control are critical for homeostasis, and it is the fundamental function of the endocrine system.

Whereas the nervous system uses neurotransmitters to communicate, the endocrine system uses **hormones** for chemical signaling. These hormone signals are sent by the endocrine organs. Hormones are transported primarily via the bloodstream throughout the body, where they bind to receptors on target cells, inducing a characteristic response. Some of the glands in the endocrine system include the pituitary, thyroid, parathyroid, adrenal, and pineal glands. See Figure 9.1 for an illustration of the endocrine system.

"1801 The Endocrine System.jpg" by OpenStax is licensed under CC BY 4.0 Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-1-an-overview-of-the-endocrine-system>

Some of these glands have both endocrine and nonendocrine functions. For example, the pancreas contains cells that function in digestion, as well as cells that secrete the hormones insulin and glucagon, which regulate blood glucose levels.

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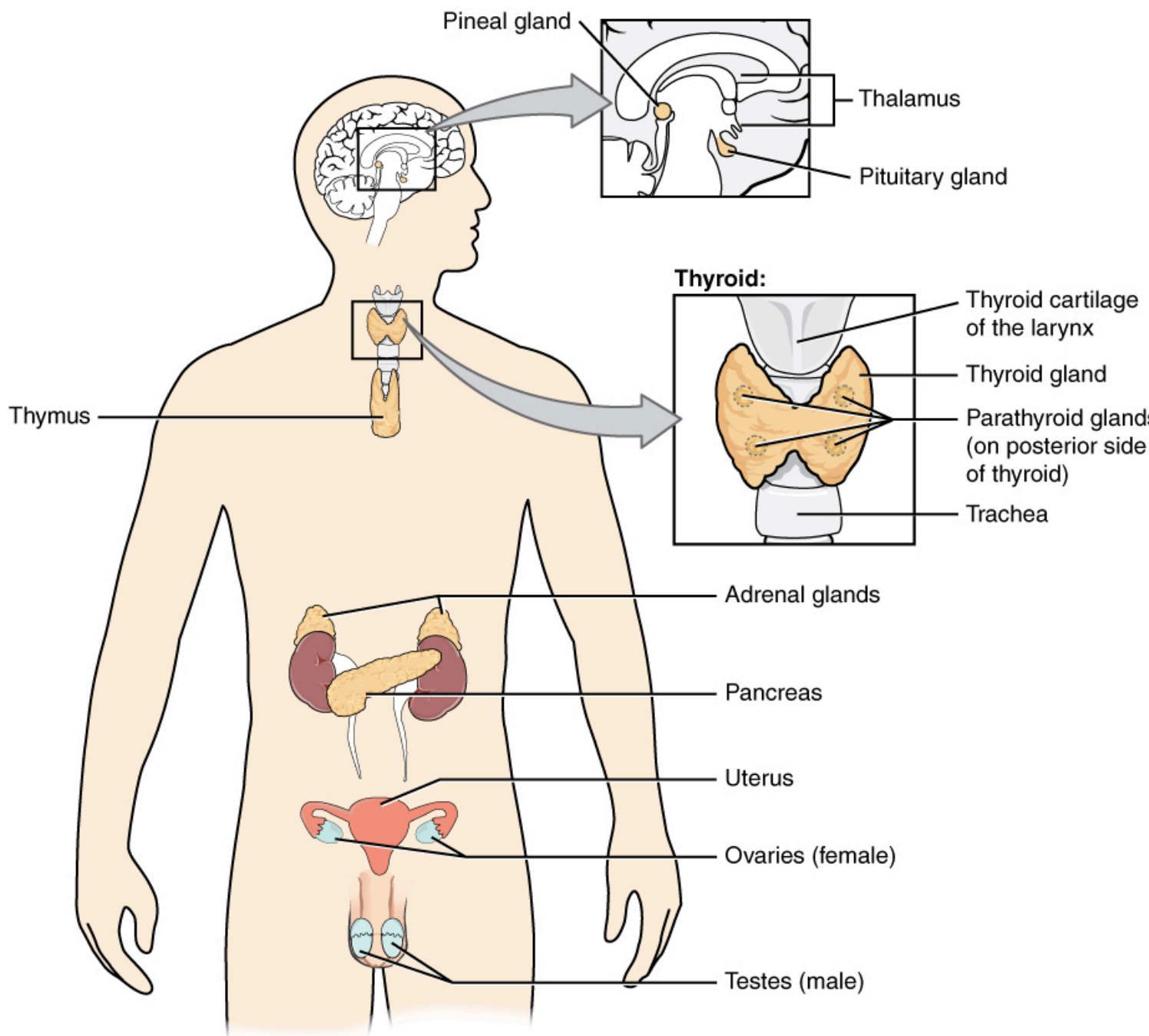


Figure 9.1 Overview of the Endocrine System

This module will focus on medications that affect three major endocrine glands and their hormones: the adrenal glands, the pancreas, and the thyroid. See Table 9.1 for a list of hormones associated with each of these glands and their effects.

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Table 9.1. Hormones Associated with Adrenal Gland, Pancreas, and Thyroid and Their Effects

Endocrine gland	Hormone	Effect
Adrenal (cortex)	Aldosterone	Increases blood Na ⁺ levels

Adrenal (cortex)	Cortisol	Increases blood sugar levels
Adrenal (medulla)	Epinephrine and Norepinephrine	Stimulates fight-or-flight response
Pancreas	Insulin	Reduces blood glucose levels
Pancreas	Glucagon	Increases blood glucose levels
Thyroid	Thyroxine (T4), triiodothyronine (T3)	Stimulates basal metabolic rate
Thyroid	Calcitonin	Reduces blood Ca ⁺ levels

Regulation of Hormone Secretion

To prevent abnormal hormone levels and a potential disease state, hormone levels must be tightly controlled. Feedback loops govern the initiation and maintenance of hormone secretion in response to various stimuli.

The most common method of hormone regulation is the **negative feedback loop**. Negative feedback is characterized by the inhibition of further secretion of a hormone in response to adequate levels of that hormone. This allows blood levels of the hormone to be regulated within a narrow range. An example of a negative feedback loop is the release of glucocorticoid hormones from the adrenal glands, as directed by the hypothalamus and pituitary gland. As glucocorticoid concentrations in the blood rise, the hypothalamus and pituitary gland reduce their signaling to the adrenal glands to prevent additional glucocorticoid secretion.

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See Figure 9.2 for an illustration of a negative feedback loop.

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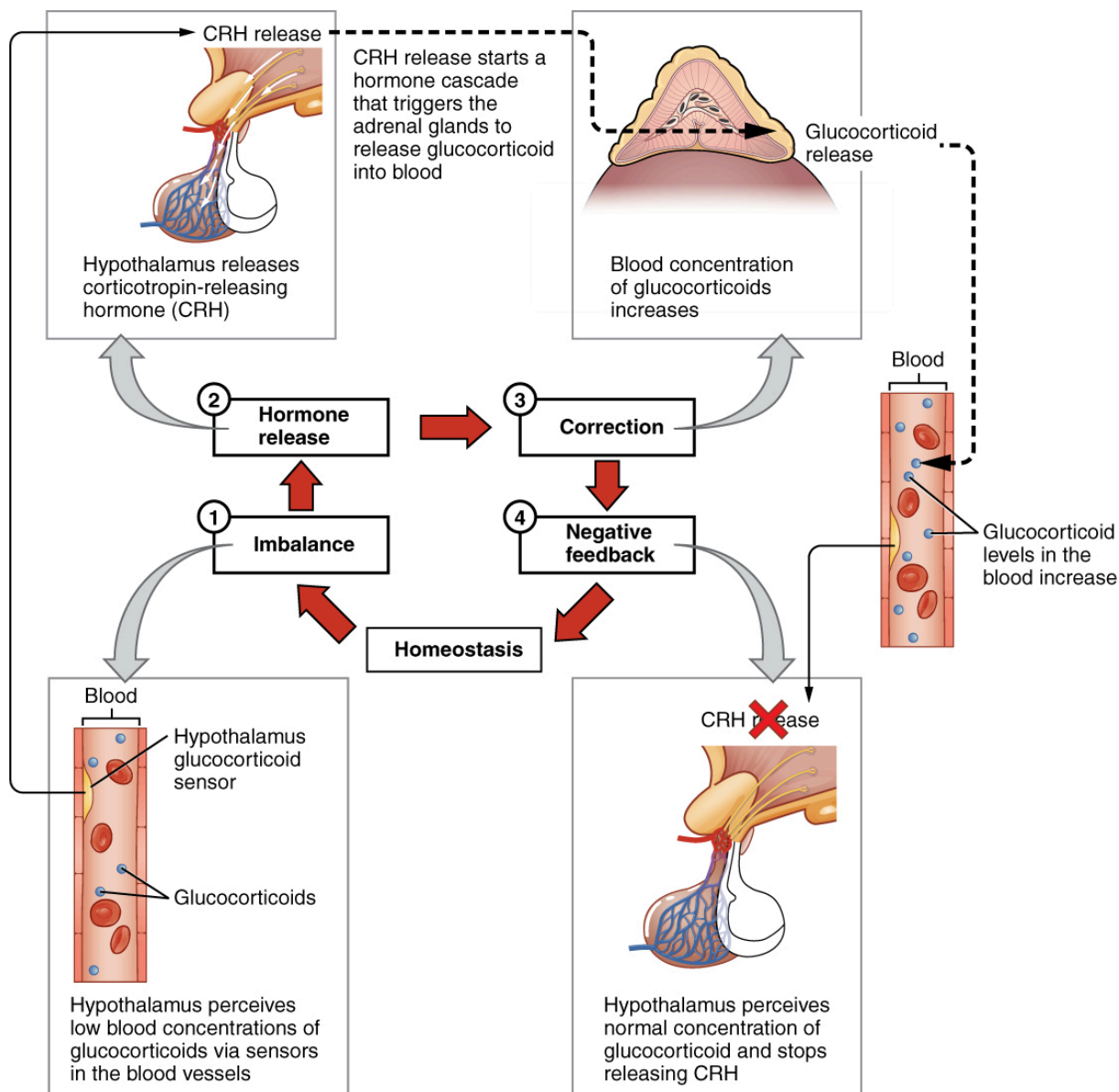


Figure 9.2 Negative Feedback Loop

Endocrine Gland Stimuli

Endocrine glands can be stimulated by humoral stimuli, by stimulation of another hormone, or by neural stimuli. **Humoral stimuli** are changes in blood levels of non-hormone chemicals that cause the release or inhibition of a hormone to maintain homeostasis. For example, osmoreceptors in the hypothalamus detect changes in **blood osmolarity** (the concentration of solutes in the blood plasma). If blood osmolarity is too high, meaning that the blood is not dilute enough, osmoreceptors signal the hypothalamus to release ADH (antidiuretic hormone). ADH causes the kidneys to reabsorb more water and reduce the volume of urine produced. This reabsorption causes a reduction of the osmolarity of the blood by diluting the blood to the appropriate level. Another example of humoral stimuli is the regulation of blood glucose. High blood glucose levels cause the release of insulin from the pancreas, which increases glucose uptake by cells and liver storage of glucose as glycogen.

An endocrine gland may also secrete a hormone in response to the presence of another hormone

produced by a different endocrine gland. For example, the thyroid gland secretes T4 into the bloodstream when triggered by thyroid-stimulating hormone (TSH) that is released from the anterior pituitary gland.

In addition to these chemical signals, hormones can also be released in response to **neural stimuli**. An example of neural stimuli is the activation of the fight-or-flight response by the sympathetic nervous system. When an individual perceives danger, sympathetic neurons signal the adrenal glands to secrete norepinephrine and epinephrine. The two hormones dilate blood vessels, increase the heart and respiratory rate, and suppress the digestive and immune systems. These responses boost the body's transport of oxygen to the brain and muscles, thereby improving the body's ability to fight or flee.

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The Hypothalamus–Pituitary Complex

The **hypothalamus–pituitary complex** can be thought of as the “command center” of the endocrine system. This complex secretes several hormones that directly produce responses in target tissues, as well as hormones that regulate the synthesis and secretion of hormones of other glands. In addition, the hypothalamus–pituitary complex coordinates the messages of the endocrine and nervous systems. In many cases, a stimulus received by the nervous system must pass through the hypothalamus–pituitary complex to be translated into hormones that can initiate a response. See Figure 9.3 for an illustration of the hypothalamus–pituitary complex.

"1806 The Hypothalamus-Pituitary Complex.jpg" by [OpenStax](#) is licensed under [CC BY 4.0](#) Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-3-the-pituitary-gland-and-hypothalamus>

The hypothalamus connects to the pituitary gland by the stalk-like infundibulum. The pituitary gland consists of an anterior and posterior lobe, with each lobe secreting different hormones in response to signals from the hypothalamus.

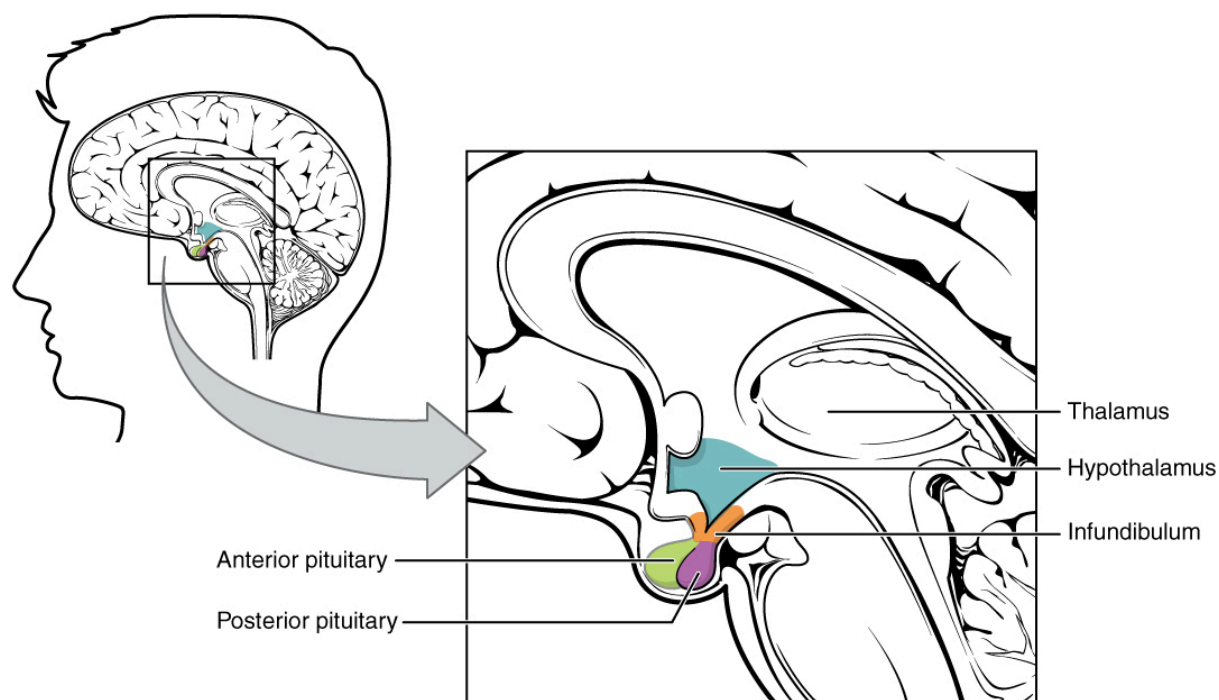


Figure 9.3 Illustration of the Hypothalamus–Pituitary Complex

Posterior Pituitary

The posterior pituitary gland does not produce hormones, but stores and secretes two hormones produced by the hypothalamus: oxytocin and antidiuretic hormone (ADH).

Antidiuretic Hormone (ADH)

Blood osmolarity, the concentration of sodium ions and other solutes, is constantly monitored by **osmoreceptors** in the hypothalamus. Blood osmolarity may change in response to the consumption of certain foods and fluids, as well as in response to disease, injury, medications, or other factors. In response to high blood osmolarity, which can occur during dehydration or following a very salty meal, the osmoreceptors signal the posterior pituitary to release antidiuretic hormone (ADH). Its effect is to cause increased water reabsorption by the kidneys. As more water is reabsorbed by the kidneys, a greater amount of water is returned to the blood, thus causing a decrease in blood osmolarity. The release of ADH is controlled by a negative feedback loop. As blood osmolarity decreases, the hypothalamic osmoreceptors sense the change and prompt a corresponding decrease in the secretion of ADH. As a result, less water is reabsorbed by the kidneys.

Drugs can also affect the secretion of ADH or imitate its effects. For example, alcohol consumption inhibits the release of ADH, resulting in increased urine production that can eventually lead to dehydration and a hangover. Vasopressin is a synthetic ADH medication used to treat very low blood pressure. It is called vasopressin because in very high concentrations it also causes constriction of blood vessels in addition to the retention of water. Vasopressin is also used to treat a disease called **diabetes insipidus (DI)** that causes dehydration due to an underproduction of ADH.

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Anterior Pituitary

In contrast to the posterior pituitary, the anterior pituitary does manufacture hormones. However, the secretion of hormones from the anterior pituitary is regulated by two classes of hormones secreted by the hypothalamus called releasing hormones. Releasing hormones then stimulate the secretion of hormones from the anterior pituitary (see Figure 9.4

"1808 The Anterior Pituitary Complex.jpg" by [OpenStax](#) is licensed under [CC BY 4.0](#). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-3-the-pituitary-gland-and-hypothalamus>

). The anterior pituitary produces seven hormones. These are the growth hormone (GH), thyroid-stimulating hormone (TSH), adrenocorticotrophic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), beta endorphin, and prolactin. Of the hormones of the anterior pituitary, TSH, ACTH, FSH, and LH are collectively referred to as **tropic hormones** (trope- = “turning”) because they turn on or off the function of other endocrine glands. This module will focus on the effects of TSH and ACTH.

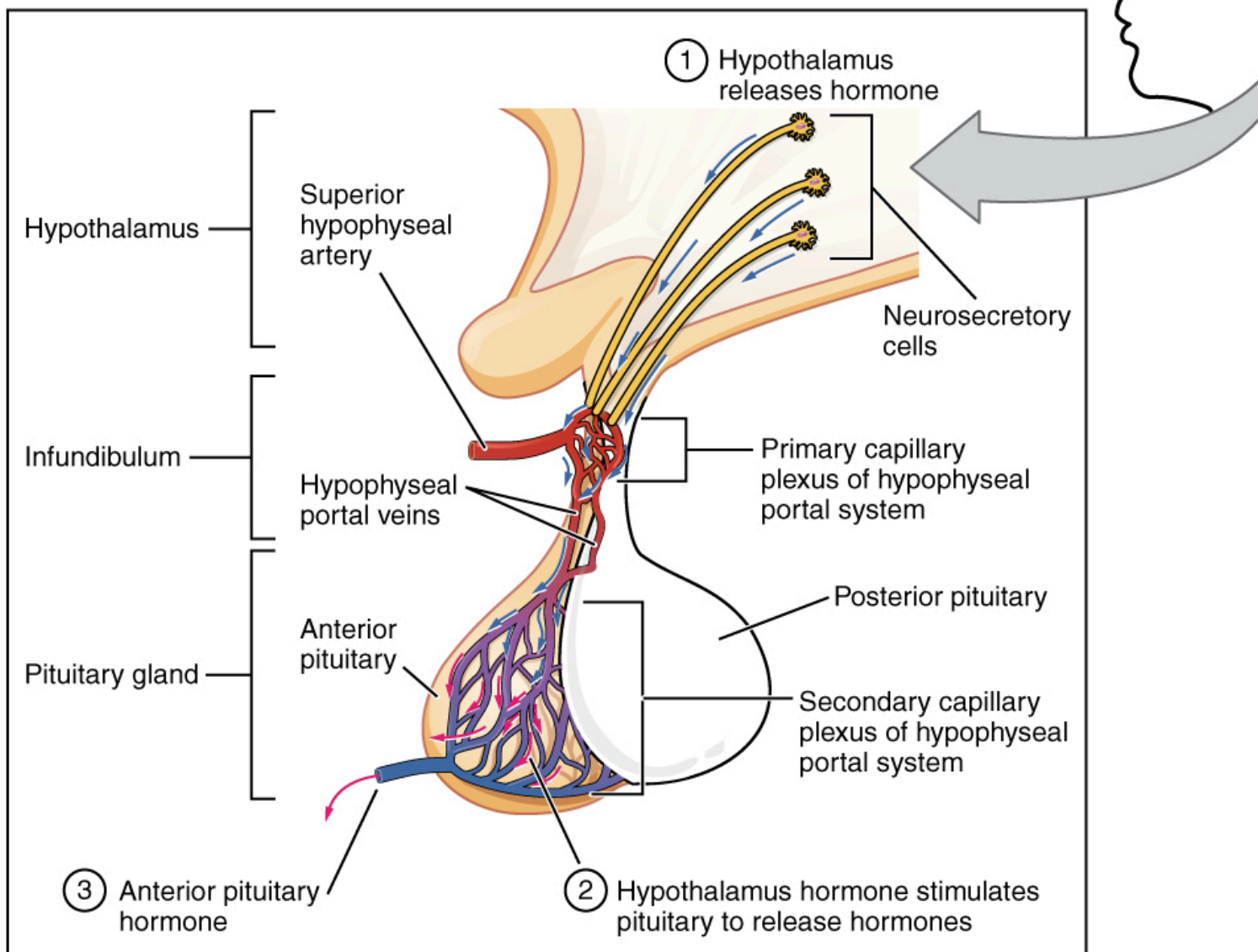


Figure 9.4 The hypothalamus releases hormones to regulate the release of hormones from the anterior pituitary

Thyroid-Stimulating Hormone (TSH)

The activity of the thyroid gland is regulated by the thyroid-stimulating hormone (TSH). TSH is released from the anterior pituitary in response to the thyrotropin-releasing hormone (TRH) from the

hypothalamus and triggers the secretion of thyroid hormones by the thyroid gland. In a classic negative feedback loop, elevated levels of thyroid hormones in the bloodstream then trigger a drop in production of TRH and subsequently, the production of TSH. TSH is further discussed in the “Thyroid” submodule.

Adrenocorticotrophic Hormone (ACTH)

The adrenocorticotrophic hormone (ACTH) is released from the anterior pituitary in response to the corticotropin-releasing hormone (CRH) from the hypothalamus. ACTH then stimulates the adrenal cortex to secrete corticosteroid hormones such as cortisol. A variety of stressors can also influence the release of ACTH, and the role of ACTH in the stress response is discussed under the “Adrenal” submodule.

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Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=1678#h5p-24>

9.3 Corticosteroids

Open Resources for Nursing (Open RN)

Adrenal: A&P Basics Review

The adrenal gland consists of the adrenal cortex that is composed of glandular tissue and the adrenal medulla that is composed of nervous tissue. Each region secretes its own set of hormones.

The adrenal cortex is a component of the **hypothalamic-pituitary-adrenal (HPA) axis**. The hypothalamus stimulates the release of ACTH from the pituitary, which then stimulates the adrenal cortex to produce steroid hormones that are important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation.

The **adrenal medulla** is neuroendocrine tissue composed of postganglionic sympathetic nervous system (SNS) neurons that secretes the hormones epinephrine and norepinephrine. It is an extension of the autonomic nervous system, which regulates homeostasis in the body. See Figure 9.5 for an illustration of the adrenal gland and associated hormones.

"1818 The Adrenal Glands.jpg" by [OpenStax](#) is licensed under [CC BY 4.0](#) Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-6-the-adrenal-glands>

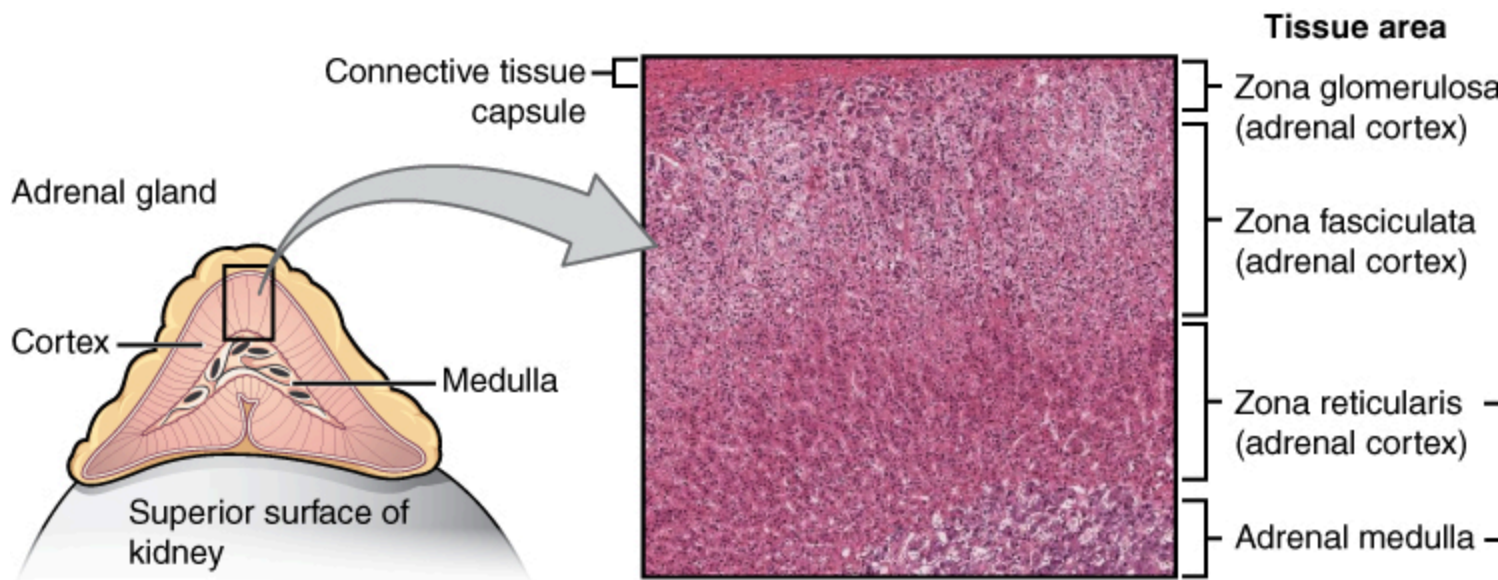


Figure 9.5 The Adrenal Gland and Associated Hormones

One of the major functions of the adrenal gland is to respond to stress. The body responds in different ways to short-term stress and long-term stress following a pattern known as the **general adaptation syndrome (GAS)**. Stage one of GAS is called the alarm reaction. This is short-term stress, also called the fight-or-flight response, and is mediated by the hormones epinephrine and norepinephrine from the adrenal medulla. Their function is to prepare the body for extreme physical exertion. If the stress is not soon relieved, the body adapts to the stress in the second stage called the stage of resistance. If a person is starving for example, the body may send signals to the gastrointestinal tract to maximize the absorption of nutrients from food. If the stress continues for a longer term however, the body responds with symptoms such as depression, suppressed immune response, or severe fatigue. These symptoms are mediated by the hormones of the adrenal cortex, especially cortisol.

Adrenal hormones also have several non-stress-related functions, including the increase of blood sodium and glucose levels, which will be described in further detail below.

Mineralocorticoids: Aldosterone

The most superficial region of the adrenal cortex is the zona glomerulosa, which produces a group of hormones collectively referred to as **mineralocorticoids** because of their effect on body minerals, especially sodium and potassium. These hormones are essential for fluid and electrolyte balance.

Aldosterone is the major mineralocorticoid that is important in the regulation of the concentration of sodium and potassium ions in the body. The secretion of aldosterone by the adrenal cortex is prompted by the HPA axis when the hypothalamus triggers ACTH release from the anterior pituitary. It is released in response to elevated blood levels of potassium (K^+), low blood levels of sodium (Na^+), low blood pressure, or low blood volume. Aldosterone targets the kidneys and increases the excretion of K^+ and the retention of Na^+ , which, in turn, causes the retention of water, thus increasing blood volume and blood pressure.

Aldosterone is also a key component of the renin-angiotensin-aldosterone system (RAAS) in which specialized cells of the kidneys secrete renin in response to low blood volume or low blood pressure. Renin then catalyzes the conversion of the blood protein angiotensinogen, which is produced by the

liver, to the hormone Angiotensin I. Angiotensin I is converted in the lungs to Angiotensin II by the angiotensin-converting enzyme (ACE). Angiotensin II has three major functions: initiating vasoconstriction of the arterioles, thus decreasing blood flow; stimulating kidney tubules to reabsorb sodium and water, thus increasing blood volume; and signaling the adrenal cortex to secrete aldosterone, which further increases blood volume and blood pressure. It is important to understand these effects because many cardiac medications target the effects of aldosterone and the RAAS system. For example, drugs that block the production of Angiotensin II are known as ACE inhibitors. ACE inhibitors are used to help lower blood pressure in patients with hypertension by blocking the ACE enzyme from converting Angiotensin I to Angiotensin II, which, in turn, causes vasodilation of the arterioles. Another medication called spironolactone is used as a diuretic because it blocks the effects of aldosterone and, thus, causes the kidneys to eliminate water and sodium to decrease blood volume and blood pressure.

Glucocorticoids: Cortisol

The intermediate region of the adrenal cortex produces hormones called glucocorticoids because of their role in glucose metabolism. In response to long-term stressors, the HPA axis triggers the release of glucocorticoids. Their overall effect is to inhibit tissue building while stimulating the breakdown of stored nutrients to maintain adequate fuel supplies. In conditions of long-term stress, cortisol promotes the catabolism of glycogen to glucose, stored triglycerides into fatty acids and glycerol, and muscle proteins into amino acids. These raw materials can then be used to synthesize additional glucose and ketones for use as body fuels. However, the negative effects of catabolism for energy can result in muscle breakdown and weakness, poor wound healing, and the suppression of the immune system.

Many medications contain glucocorticoids to treat various conditions, such as cortisone injections for inflamed joints; prednisone tablets, IV medication, and steroid-based inhalers to manage inflammation that occurs in asthma; and hydrocortisone creams that are applied to relieve itchy skin rashes.

Androgens

The deepest region of the adrenal cortex produces small amounts of a class of steroid sex hormones called androgens. During puberty and most of adulthood, androgens are produced in the gonads. The androgens produced in the adrenal cortex supplement the gonadal androgens.

Adrenal Medulla: Epinephrine and Norepinephrine

As noted earlier, the adrenal cortex releases glucocorticoids in response to long-term stress such as severe illness. In contrast, the adrenal medulla releases its hormones in response to acute, short-term stress mediated by the sympathetic nervous system (SNS). The medullary tissue is composed of unique postganglionic SNS neurons called chromaffin cells that produce the neurotransmitters epinephrine (also called adrenaline) and norepinephrine (also called noradrenaline), which are chemically classified as catecholamines. Epinephrine is produced in greater quantities and is the more powerful hormone.

The secretion of medullary epinephrine and norepinephrine is controlled by a neural pathway that originates from the hypothalamus in response to danger or stress. Both epinephrine and norepinephrine increase the heart rate, pulse, and blood pressure to prepare the body to fight the perceived threat or flee from it. In addition, the pathway dilates the airways, raising blood oxygen levels. It also prompts vasodilation, further increasing the oxygenation of important organs such as the lungs, brain, heart, and skeletal muscle while also prompting vasoconstriction to blood vessels serving less essential organs such as the gastrointestinal tract, kidneys, and skin. It also downregulates some components of the immune

system. Other effects include a dry mouth, loss of appetite, pupil dilation, and a loss of peripheral vision.

Disorders Involving the Adrenal Glands

Several disorders are caused by the dysregulation of the hormones produced by the adrenal glands. For example, Cushing's disease is a disorder characterized by high blood glucose levels, the development of a moon-shaped face, a buffalo hump on the back of the neck, rapid weight gain, and hair loss. It is caused by hypersecretion of cortisol. Cushing's syndrome can also be caused by long-term use of corticosteroid medications.

In contrast, the hyposecretion of corticosteroids can result in Addison's disease, a disorder that causes low blood glucose levels and low blood sodium levels. Addisonian crisis is a life-threatening condition due to severely low blood pressure resulting from a lack of corticosteroid levels.

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Nieman, L., Biller, B., Findling, J., Murad, M., Newell-Price, J., Savage, M., & Tabarin, A. (2015, August 1). Treatment of Cushing's Syndrome: an endocrine clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 100(8). pp. 2807-2831. <https://academic.oup.com/jcem/article/100/8/2807/2836065>

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Liu, D., Ahmet, A., Ward, L., et al (2013). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology*, 9, 30. <https://aacijournal.biomedcentral.com/articles/10.1186/1710-1492-9-30>

A supplementary video about ACTH and the adrenal gland is provided below.

ACTH and the Adrenal Gland

Forcica, B. (2015, May 12). *Anatomy and Physiology: Endocrine System: ACTH (Adrenocorticotropin Hormone) V2.0*. [Video]. YouTube. All rights reserved. Video used with permission. <https://youtu.be/4m7XfIJzm2w>.

One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/pharmacology/?p=1683#oembed-1>

Nursing Considerations for Adrenal Medications

Assessment

Before initiating long-term systemic corticosteroid therapy, a thorough history and physical examination should be performed to assess for risk factors or pre-existing conditions that may potentially be exacerbated by glucocorticoid therapy, such as diabetes, dyslipidemia, cerebrovascular disease (CVD), GI disorders, affective disorders, or osteoporosis. At a minimum, baseline measures of body weight, height, bone mineral density, and blood pressure should be obtained, along with laboratory assessments that include a complete blood count (CBC), blood glucose values, and lipid profile. In children, nutritional and pubertal status should also be examined. Symptoms of and/or exposure to serious infections should also be assessed as corticosteroids are contraindicated in patients with untreated systemic infections. Concomitant use of other medications should also be assessed before initiating therapy as significant drug interactions have been noted between glucocorticoids and several drug

classes. Females of childbearing age should also be questioned about the possibility of pregnancy because use in pregnancy may increase the risk of cleft palate in offspring.

Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology*, 9(30). <https://doi.org/10.1186/1710-1492-9-30>

Implementation

Long-term corticosteroid therapy should never be stopped abruptly due to its effect on the hypothalamic-pituitary-adrenal (HPA) axis and potential adrenal suppression. Instead, the dose should be tapered to allow the body to resume natural production of adrenal hormone levels.

Patients on long-term corticosteroid therapy who are also at high risk for fractures are recommended to receive concurrent pharmacological treatment for osteoporosis. Alendronate, a bisphosphonates class of medication, is often used in addition to other osteoporosis preventative measures such as weight-bearing exercise and calcium/Vitamin D supplementation.

Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology*, 9(30). <https://doi.org/10.1186/1710-1492-9-30>

Evaluation

The lowest effective dose should be used for treatment of the underlying condition, and the dose should be re-evaluated regularly to determine if further reductions can be instituted.

The parameters described under “Assessment” should be monitored regularly. Health care professionals should monitor for adrenal suppression in patients who have been treated with corticosteroids for greater than two weeks or in multiple short courses of high-dose therapy. Symptoms of adrenal insufficiency include weakness/fatigue, malaise, nausea, vomiting, diarrhea, abdominal pain, headache (usually in the morning), poor weight gain and/or growth in children, myalgia, arthralgia, psychiatric symptoms, hypotension, and hypoglycemia. If these symptoms occur, further lab work, such as an early morning cortisol test, should be performed.

Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology*, 9(30). <https://doi.org/10.1186/1710-1492-9-30>

Adrenal Medication: Corticosteroids

Indications Corticosteroids are used as replacement therapy in adrenal insufficiency, as well as for the management of various dermatologic, ophthalmologic, rheumatologic, pulmonary, hematologic, and gastrointestinal (GI) disorders. In respiratory conditions, systemic corticosteroids are used for the treatment of acute exacerbations of chronic obstructive pulmonary disease (COPD) and severe asthma. Mineralocorticoids are primarily involved in the regulation of electrolyte and water balance. Glucocorticoids are predominantly involved in carbohydrate, fat, and protein metabolism and also have anti-inflammatory, immunosuppressive, anti-proliferative, and vasoconstrictive effects. Prednisone is perhaps the most widely used of the systemic corticosteroids. It is generally used as an anti-inflammatory and immunosuppressive agent. Hydrocortisone is a commonly used topical cream for itching, and its oral formulation is used to treat Addison’s disease.

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Methylprednisolone is a commonly used injectable corticosteroid. Fludrocortisone has much greater

mineralocorticoid potency and, therefore, is commonly used to replace aldosterone in Addison's disease. Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology*, 9(30). <https://doi.org/10.1186/1710-1492-9-30>

See Figure 9.6 for images of various formulations of corticosteroids.

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"Methylprednisolone vial.jpg" by [Intropin](#) is licensed under [CC BY 3.0](#)

"006035339lg Prednisone 20 MG Oral Tablet.jpg" by NLM is licensed under [CC0](#)







Figure 9.6 Examples of Corticosteroid Medications (fluticasone inhaler, intravenous methylprednisolone, and prednisone tablets)

Corticosteroids are used for a variety of disorders such as:

- Endocrine disorders such as adrenocortical insufficiency
- Rheumatic disorders such as rheumatoid arthritis
- Collagen diseases such as systemic lupus erythematosus
- Dermatologic diseases such as severe psoriasis
- Allergic states such as contact dermatitis or drug hypersensitivity reactions
- Ophthalmic diseases such as optic neuritis
- Respiratory diseases such as asthma or COPD
- Neoplastic diseases such as leukemia
- Gastrointestinal diseases such as ulcerative colitis
- Nervous system diseases such as multiple sclerosis

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Mechanism of Action Glucocorticoids cause profound and varied metabolic effects as described in the “Adrenal A&P Basics Review” section earlier. In addition, they modify the body’s immune responses.

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Specific Administration Considerations Despite their beneficial effects, long-term systemic use of corticosteroids is associated with well-known adverse events, including osteoporosis and fractures, adrenal suppression, hyperglycemia and diabetes, cardiovascular disease and dyslipidemia, dermatological and GI events, psychiatric disturbances, and immunosuppression. One side effect that is unique to children is growth suppression.

Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013,

August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology*, 9(30). <https://doi.org/10.1186/1710-1492-9-30>

Therefore, the lowest possible dose of corticosteroid should be used to control the condition under treatment to avoid the development of these adverse effects. When reduction in dosage is possible, the reduction should be gradual and should not be stopped abruptly because of the associated HPA suppression that occurs with long-term administration. This hypothalamus-pituitary-adrenal (HPA) suppression can cause an impaired stress response, which may persist for months after discontinuation of therapy; therefore, in any situation of stress occurring during that period, hormone therapy should be reinstituted. Alternate day therapy is a corticosteroid dosing regimen in which twice the usual daily dose of corticoid is administered every other morning. The purpose of this mode of therapy is to minimize undesirable effects that can occur during long-term administration.

Dosages are variable and tailored to the disease process and the individual. **Adverse/side effects**

Adverse/side effects of corticosteroids include fluid and electrolyte imbalances; muscle weakness; peptic ulcers; thin, fragile skin that bruises easily; poor wound healing; and the development of Cushing's syndrome. Corticosteroids may mask some signs of infection, and new infections may appear during their use. Psychic derangements may appear when corticosteroids are used, ranging from euphoria, insomnia, mood swings, personality changes to severe depression. **Patient Teaching & Education** Teach patients taking long-term prednisone therapy to never abruptly stop taking the medication and to report any adverse/side effects or new signs of infection.

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Glucocorticoid medication can cause immunosuppression, which makes it more difficult to detect signs of infection. Patients should seek advice from healthcare providers regarding vaccination administration while on glucocorticoids. Patients should report unusual swelling, weight gain, fatigue, bone pain, bruising, non-healing sores, visual and behavioral disturbances to the provider.

Use of glucocorticoid therapy may cause an increase in blood glucose levels. Patients should be advised to consume diets that are high in protein, calcium, and potassium.

Now let's take a closer look at the medication grid comparing different formulations of corticosteroids in Table 9.3.

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AHFS Patient Medication Information [Internet]. Bethesda (MD): American Society of Health-System Pharmacists, Inc.; c2019. *Neomycin, Polymyxin, Bacitracin, and Hydrocortisone Topical*; [reviewed 2018 Jun 15]. <https://medlineplus.gov/druginfo/meds/a601061.html>

Bornstein, S., Allolio, B., Arlt, W., Barthel, A., Don-Wauchope, A., Hammer, G., Husebye, E., Merke, D., Murad, M., Stratakis, C., & Tropy, D. (2016, February 1). Diagnosis and treatment of primary adrenal insufficiency: an endocrine society clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 101(2). pp. 364-389. <https://doi.org/10.1210/jc.2015-1710>

Nieman, L., Biller, B., Findling, J., Murad, M., Newell-Price, J., Savage, M., & Tabarin, A. (2015, August 1). Treatment of Cushing's Syndrome: an endocrine clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 100(8). pp. 2807-2831. <https://academic.oup.com/jcem/article/100/8/2807/2836065>

Liu, D., Ahmet, A., Ward, L., Krishnamoorthy, P., Mandelcorn, E., Leigh, R., Brown, J., Cohen, A., & Kim, H. (2013, August 15). A practical guide to the monitoring and management of the complications of systemic corticosteroid therapy. *Allergy, Asthma & Clinical Immunology*, 9(30). <https://doi.org/10.1186/1710-1492-9-30>

Medication grids are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based

resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below. Detailed information on a specific medication can be found for free at Daily Med at <https://dailymed.nlm.nih.gov/dailymed/index.cfm>. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also hyperlinked directly to a Daily Med page.

Table 9.3 Medication Grid Comparing Prednisone, Methylprednisolone, Hydrocortisone, and Fludrocortisone

Class	Prototypes/ generics	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Glucocorticoid	prednisone (PO) methylprednisolone (IV)	Never abruptly stop corticosteroid therapy	Often used to reduce inflammation or for immunosuppression	Fluid and electrolyte imbalances
		Use the lowest dose possible to control disorder and taper when feasible		Increase in blood glucose
		May require concurrent treatment for osteoporosis or elevated blood glucose levels		Muscle weakness
		Regularly monitor for development of symptoms of adrenal suppression		Peptic ulcers
Topical Glucocorticoid	hydrocortisone cream	Contraindicated in patients with untreated systemic infections	Cream: topical relief of itching, redness, and swelling	Thin, fragile skin that bruises easily
		Cream is only for use on the skin. Do not use in eyes		Poor wound healing
		Apply a small amount of		Development of Cushing's syndrome
				May mask some signs of infection, and new infections may appear
				Psychic derangements may appear when corticosteroids are used, ranging from euphoria, insomnia, mood swings, personality changes to severe depression
				Contact the provider if no improvement within 7 days

medication to cover the affected area of skin with a thin, even film and rub in gently

Do not wrap or bandage the treated area unless included in the prescription

Symptoms should begin to improve during the first few days of treatment; do not use this medication longer than 7 days unless directed

Often administered in conjunction with cortisone or hydrocortisone

Contraindicated if systemic fungal infection present

Mineralocorticoid [fludrocortisone](#)

Continually monitor for signs that indicate dosage adjustment is necessary, such as exacerbations of the disease or stress (surgery, infection, trauma)

Aldosterone replacement in Addison's disease

Potential adverse effects from retention of sodium and water: hypertension, edema, cardiac enlargement, congestive heart failure, potassium loss, and hypokalemic alkalosis

Image of lightbulb

Critical Thinking Activity 9.3 in a circle

A patient in a long-term care facility who has COPD receives prednisone 10 mg daily to help manage her respiratory status. Upon reviewing the patient's chart, the nurse notices that the patient was diagnosed with osteoporosis in the past, but is not currently receiving medications indicated for osteoporosis. The nurse is concerned because the patient requires assistance and is a fall risk so the nurse plans to call the provider.

1. What cues in the patient's medical history cause the nurse to be concerned about the risk for a fracture?
2. What medication(s) may be prescribed concurrently with prednisone to reduce the risk for a fracture?
3. What other patient teaching can the nurse provide to help reduce the patient's risk for a fracture?
4. Bedside glucose testing with sliding scale insulin is ordered for this patient, although she has no history of diabetes mellitus. What is the rationale for these orders?
5. What cues would cause the nurse to contact the provider with the hypothesis that adrenal suppression is occurring?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

9.4 Antidiabetics

Open Resources for Nursing (Open RN)

Pancreatic Basics: A&P Review

Pancreas

The pancreas is a long, slender organ located near the stomach (see Figure 9.7).

"1820 The Pancreas.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-9-the-endocrine-pancreas>

Although it is primarily an **exocrine gland**, secreting a variety of digestive enzymes, the pancreas also has an endocrine function. Pancreatic islets, clusters of cells formerly known as the islets of Langerhans, secrete glucagon and insulin. Glucagon plays an important role in blood glucose regulation because low blood glucose levels stimulate its release. On the other hand, elevated blood glucose levels stimulate the release of insulin.

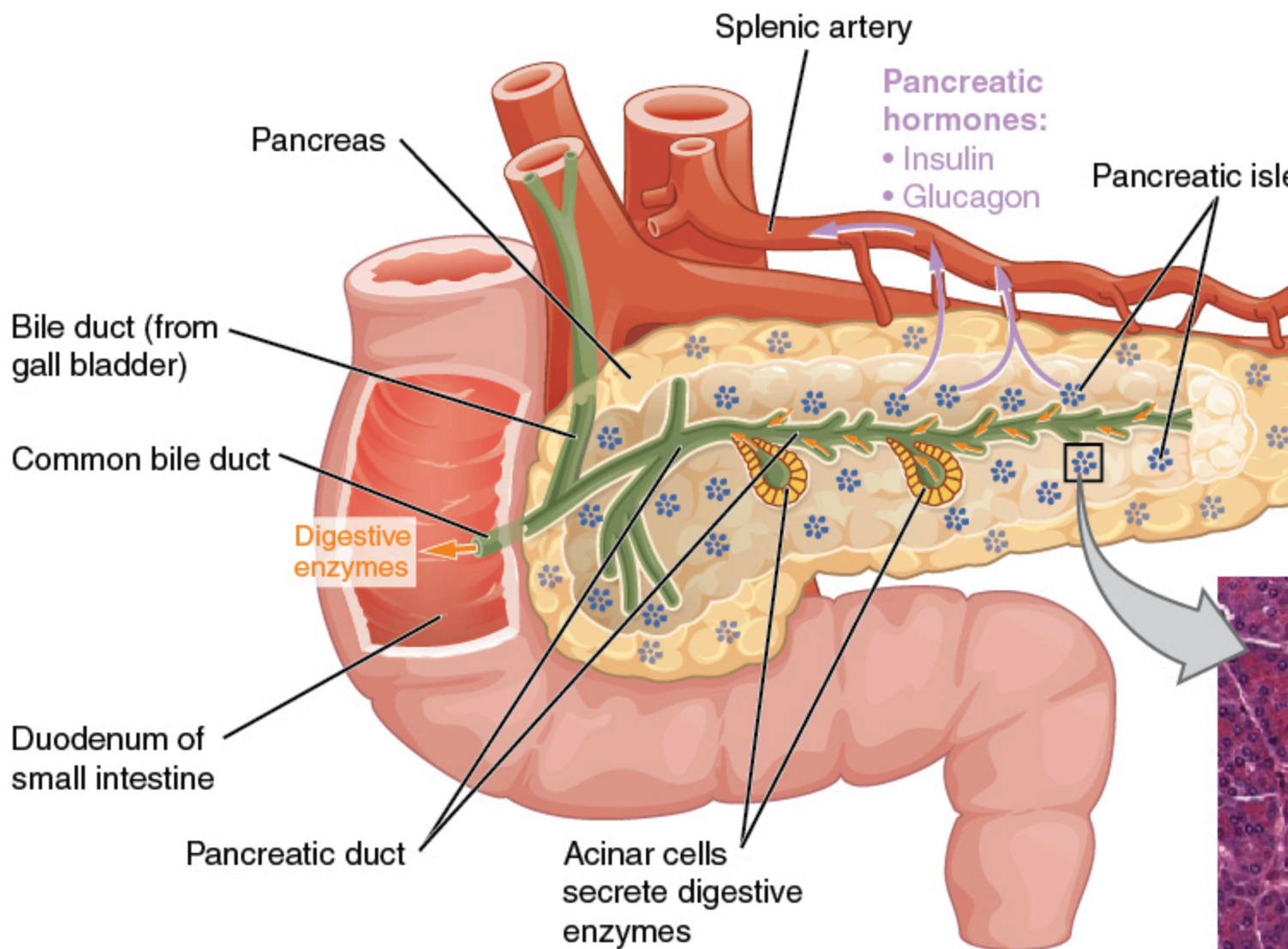


Figure 9.7 Pancreas

Regulation of Blood Glucose Levels by Insulin and Glucagon

Glucose is the preferred fuel for all body cells. The body derives glucose from the breakdown of the carbohydrate-containing foods and drinks we consume. Glucose not immediately taken up by cells for fuel can be stored by the liver and muscles as glycogen or converted to triglycerides and stored in the adipose tissue. Hormones regulate both the storage and the utilization of glucose as required. Receptors located in the pancreas sense blood glucose levels, and subsequently, the pancreatic cells secrete glucagon or insulin to maintain normal levels.

Glucagon

Receptors in the pancreas can sense the decline in blood glucose levels, such as during periods of fasting or during prolonged labor or exercise. In response, the alpha cells of the pancreas secrete the hormone glucagon, which has several effects:

- It stimulates the liver to convert stores of glycogen back into glucose. This response is known as

glycogenolysis. The glucose is then released into the circulation for use by body cells.

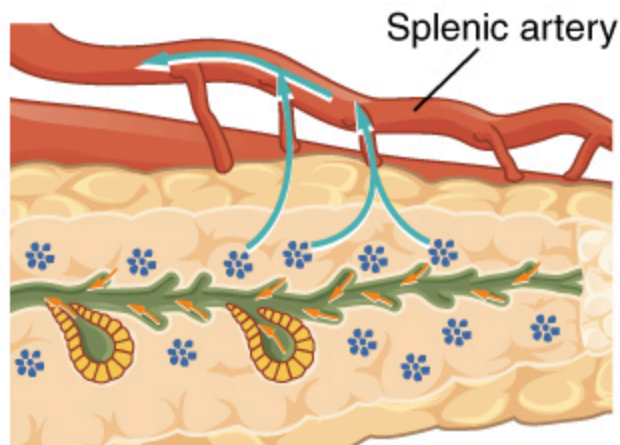
- It stimulates the liver to take up amino acids from the blood and convert them into glucose. This response is known as gluconeogenesis.
- It stimulates lipolysis, the breakdown of stored triglycerides into free fatty acids and glycerol. Some of the free glycerol released into the bloodstream travels to the liver, which converts it into glucose. This is also a form of gluconeogenesis.

Taken together, these actions increase blood glucose levels. The activity of glucagon is regulated through a negative feedback mechanism; rising blood glucose levels inhibit further glucagon production and secretion. (See Figure 9.8 for an illustration of homeostatic regulation of blood glucose levels.)

"1822 The Homostatic Regulation of Blood Glucose Levels.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-9-the-endocrine-pancreas>

Insulin release:

- Beta cells of pancreas release insulin

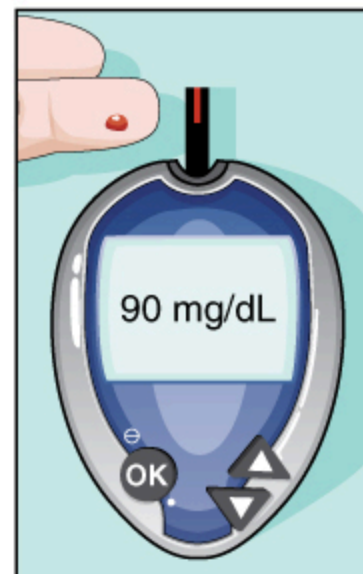


Insulin effects:

- Triggers body to release glucose from liver and utilize it in cells
- Inhibits glycogenolysis – glucose is not released from blood and stored in the liver
- Inhibits gluconeogenesis – amino acids are NOT converted to glucose in the liver



Hyperglycemia
(elevated blood glucose)



START: Homeostasis
(70–110 mg/dL)

Hypoglycemia
(low blood glucose)



Figure 9.8 Homeostatic Regulation of Blood Glucose Levels. Blood glucose concentration is tightly maintained between 70 and 100 mg/dL. If blood glucose concentration rises above this range, insulin is released, which stimulates body cells to remove glucose from the blood. If blood glucose concentration falls below this range, glucagon is released, which stimulates body cells to release glucose into the blood.

Insulin

Insulin facilitates the uptake of glucose into skeletal and adipose body cells. The presence of food in the intestine triggers the release of gastrointestinal tract hormones. This, in turn, triggers insulin production and secretion by the beta cells of the pancreas. Once nutrient absorption occurs, the resulting surge in blood glucose levels further stimulates insulin secretion.

Insulin triggers the rapid movement of glucose transporter vesicles to the cell membrane, where they are exposed to the extracellular fluid. The transporters then move glucose by facilitated diffusion into the cell interior.

Insulin also reduces blood glucose levels by stimulating **glycolysis**, the metabolism of glucose for generation of ATP. It further stimulates the liver to convert excess glucose into glycogen for storage, and it inhibits enzymes involved in glycogenolysis and gluconeogenesis. Finally, insulin promotes triglyceride and protein synthesis. The secretion of insulin is regulated through a negative feedback mechanism. As blood glucose levels decrease, further insulin release is inhibited.

Disorders of the Endocrine System: Diabetes Mellitus

Dysfunction of insulin production and secretion, as well as the target cells' responsiveness to insulin, can lead to a condition called diabetes mellitus, a common disease that affects the ability of the body to produce and/or utilize insulin. There are two main forms of diabetes mellitus. **Type 1 diabetes** is an autoimmune disease affecting the beta cells of the pancreas. The beta cells of people with type 1 diabetes do not produce insulin; thus, synthetic insulin must be administered by injection or infusion. **Type 2 diabetes** accounts for approximately 95 percent of all cases. It is acquired, and lifestyle factors such as poor diet and inactivity greatly increase a person's risk. In type 2 diabetes, the body's cells become resistant to the effects of insulin. In response, the pancreas increases its insulin secretion, but over time, the beta cells become exhausted. In many cases, type 2 diabetes can be reversed by moderate weight loss, regular physical activity, and consumption of a healthy diet. However, if blood glucose levels cannot be controlled, oral diabetic medication is implemented and eventually the type 2 diabetic may require insulin.

Diabetes is diagnosed when lab tests reveal that blood glucose levels are higher than normal, a condition called **hyperglycemia**.

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According to the American Diabetes Association (ADA), normal fasting blood glucose levels are 80-130 mg/dL. Glycosylated hemoglobin, also called A1C, is used to assess long-term blood glucose levels over 3 months. The ADA states that A1C target levels vary according to age and health, but the generalized A1C target is less than 7%.

American Diabetes Association. (2019). The Big Picture: Checking your Blood Glucose. <https://www.diabetes.org/diabetes/medication-management/blood-glucose-testing-and-control/checking-your-blood-glucose>

Nursing Considerations

Assessment

Diabetic patients should be continuously monitored for signs of hypoglycemia and hyperglycemia. When a diabetic patient is experiencing stress or an infection, the nurse should plan to assess the blood glucose levels more frequently.

Implementation

The nurse should follow agency policy and ISMP guidelines for safe insulin administration. See the “Legal Ethical” chapter for more information about ISMP guidelines. Onset and peak times of insulin and sulfonylureas, in association with anticipated meal times, should always be considered to avoid hypoglycemia episodes. If a hypoglycemia episode occurs, the nurse should intervene quickly using the agency’s established hypoglycemia protocol, and the event should be reported to the provider and in the shift-to-shift report. Symptomatic hyperglycemia should be immediately reported to the provider. Patient education should be provided to patients, family members, and/or caregivers according to ADA and ISMP guidelines.

Evaluation

The nurse should evaluate A1C levels to determine effectiveness (and compliance with) the treatment regimen.

Diabetic Medication Classes: Insulins

Because the hallmark of type 1 diabetes is absent or near-absent β -cell function, insulin treatment is essential for individuals with type 1 diabetes. Current evidence-based recommendations regarding pharmacological treatment of type 1 diabetes from the American Diabetes Association (ADA) include:

- Most people with type 1 diabetes should be treated with multiple daily injections of prandial and basal insulin or continuous subcutaneous insulin infusion.
- Most individuals with type 1 diabetes should use rapid-acting insulin analogs to reduce hypoglycemia risk.
- Individuals with type 1 diabetes on prandial insulin doses should be educated on carbohydrate intake, premeal blood glucose levels, and anticipated physical activity.
- Individuals with type 1 diabetes who have been successfully using continuous subcutaneous insulin infusion should have continued access to this therapy after they turn 65 years of age.

Basal insulin can be long-acting (insulin glargine or insulin detemir) or intermediate-acting (insulin isophane suspension [NPH]). **Prandial insulins** are used with meals and may be rapid acting (insulin lispro, insulin aspart, or insulin glulisine) or short acting (regular insulin).

According to the ADA, insulin requirements can be estimated based on weight, with typical doses ranging from 0.4 to 1.0 units/kg/day. Higher amounts are required during puberty, pregnancy, and medical illness. Physiologic insulin secretion varies with glycemia, meal size, and tissue demands for glucose. To approach this variability in people using insulin treatment, strategies have evolved to adjust

meal-time doses based on predicted needs. Thus, education of patients on how to adjust insulin to account for carbohydrate intake, premeal glucose levels, and anticipated activity is important. Ensuring that patients and/or caregivers understand correct insulin injection technique is also important to optimize glucose control and insulin use safety.

American Diabetes Association. (2019). 9. Pharmacologic Approaches to Glycemic Treatment: Standards of Medical Care in Diabetes—2019. *Diabetes Care* 42(S1). <https://doi.org/10.2337/dc19-S009>

Patients on insulin therapy are at risk for **hypoglycemia**. It is essential for the nurse to monitor for signs of hypoglycemia and to intervene appropriately. See Figure 9.9 for symptoms of hypoglycemia. Hypoglycemia is defined as a blood glucose level below 70 mg/dL; severe hypoglycemia refers to a blood glucose level below 40 mg/dL.

Hypoglycemia Symptoms

Mild-to-Moderate

- Shaky or jittery
- Sweaty
- Hungry
- Headache
- Blurred vision
- Sleepy or tired
- Dizzy or lightheaded
- Confused or disoriented
- Pale
- Uncoordinated
- Irritable or nervous
- Argumentative or combative
- Changed behavior or personality
- Trouble concentrating
- Weak
- Fast or irregular heart beat

Severe

- Unable to eat or drink
- Seizures or convulsions (jerky movements)
- Unconsciousness

Figure 9.9 Hypoglycemia Symptoms

If a patient with diabetes shows a sudden change in mood or mental status or other symptoms of hypoglycemia, the nurse should immediately check the blood glucose level. Healthcare agencies use hypoglycemia protocols so that the nurse can react quickly to episodes of hypoglycemia before they become severe. Hypoglycemia protocols contain orders for immediate treatment by the nurse. For instance, in patients who can tolerate oral intake, 15 grams of rapidly digested carbohydrates (such as 4 ounces of fruit juice) are recommended. In patients who are NPO or can't take oral treatment, dextrose 50% IV or glucagon IM or subcutaneously are administered. Patients who have had a hypoglycemic episode should be monitored closely for the following 24 hours because they are at increased risk for another episode. The provider and the oncoming nurse should be notified of hypoglycemia episodes to discuss the possible cause of the hypoglycemic event and make insulin adjustments, if needed, to avoid additional hypoglycemia. Tracking hypoglycemia episodes and analyzing causes are important performance improvement activities.

Seggelke, S., Everhart, B. (2012, September 11) Managing glucose levels in hospital patients. *American Nurse Today*.

The arrival of continuous glucose monitors to clinical practice has been proven to reduce nocturnal hypoglycemia in people using insulin pumps with glucose sensors due to automatic suspension of insulin delivery at a preset glucose level. The U.S. Food and Drug Administration has also approved the first hybrid closed-loop pump system.

American Diabetes Association. (2019). 9. Pharmacologic Approaches to Glycemic Treatment: Standards of Medical Care in Diabetes—2019. *Diabetes Care* 42(S1). <https://doi.org/10.2337/dc19-S009>

A hybrid closed-loop pump system automatically adjusts basal insulin delivery every 5 minutes based on sensor glucose to maintain blood glucose levels as close to a specific target as possible.

Weaver, H., Hirsch, I (2018, June 6). The Hybrid Closed Loop System: Evolution and Practical Applications. *Diabetes Technology & Therapeutics* 20(S2). <https://www.liebertpub.com/doi/10.1089/dia.2018.0091>.

According to the ADA, lifestyle modifications that improve health should be emphasized, along with any pharmacologic therapy. Lifestyle modifications include healthy food choices to stabilize blood glucose levels, as well as daily exercise.

Hypokalemia

All insulin products cause a shift in potassium from the extracellular to intracellular space, which can possibly lead to hypokalemia. Untreated hypokalemia may cause respiratory paralysis, ventricular arrhythmia, and death. Monitor potassium levels in patients at risk for hypokalemia due to other medications such as diuretics.

Insulin Pens

Insulin pens are often used in inpatient settings, as well as for self-administration, to facilitate safe and accurate self-administration of insulin. See Figure 9.10 for an image of an insulin pen.

"Human insulin 100 IU-1ml pen yellow background (02).jpg" by [Wesalius](#) is licensed under [CC BY 4.0](#)

According to the ISMP, insulin pens offer several advantages over vials beyond dosing accuracy, convenience, and ease of use:

- Each pen is already labeled by the manufacturer with the product name and product barcode (whereas syringes of insulin prepared on the patient care unit from vials run the risk of being unlabeled).
- Each pen can be individually labeled with the patient's name (and ideally with a patient-specific barcode).
- The pen provides the patient's insulin in a form ready for administration.
- The pen lessens nursing time needed to prepare and administer insulin.
- Insulin pens reduce medication waste that can occur when dispensing 10 mL-sized insulin vials for each patient.

However, improper sharing of insulin pens among multiple patients has exposed patients to bloodborne pathogens. Insulin pens should never be reused for multiple patients; even if the needle is changed between patients, there can still be body fluid exposure.

Institute for Safe Medication Practices. (2017). ISMP Guidelines for Optimizing Safe Subcutaneous Insulin Use in Adults. <https://www.ismp.org/sites/default/files/attachments/2017-11/ISMP138-Insulin%20Guideline-051517-2-WEB.pdf>



Figure 9.10 Insulin Pens

High-Alert Medication and Prevention of Errors

Insulin is a high-alert medication that can be associated with significant patient harm when used in error. A variety of error types have been associated with insulin therapy, including administration of the wrong insulin product, improper dosing (underdosing and overdosing), dose omissions, incorrect use of insulin delivery devices, wrong route (intramuscular versus subcutaneous), and improper patient monitoring. Many errors result in serious hypoglycemia or hyperglycemia. Hypoglycemia is often caused by a failure to adjust insulin therapy in response to a reduction in nutritional intake or an excessive insulin dose stemming from a prescribing or dose measurement error. Other factors that contribute to serious hypoglycemia include inappropriate timing of insulin doses with food intake, creatinine clearance, body weight, changes in medications that affect blood glucose levels, poor communication during patient transfer to different care teams, and poor coordination of blood glucose testing with insulin administration at meal time.

In an inpatient setting, manifestations of poor glycemic control, including severe hypoglycemia and hyperglycemia, are deemed hospital-acquired conditions by the Centers for Medicare and Medicaid Services (CMS). CMS notes that poor glycemic control can be reasonably prevented with implementation of evidence-based guidelines; thus, the CMS denies payment for diabetic ketoacidosis, hypoglycemic coma, and other serious conditions related to poor glycemic control. Agency policies and procedures should be closely followed to avoid these errors and manifestations of poor glycemic control.

One strategy for look-alike medications such as Humalog and Humalin is tall man lettering on the label. Tall man lettering describes a method for differentiating the unique letter characters of similar drug names known to be confused with one another, such as HumaLOG and HumaLIN.

ISMP recommends the following safe practice guidelines for the administration of insulin by the nurse:

- Patient-specific insulin pens are stored on clinical units in a manner that prevents their inadvertent use on more than one patient.
- A coordinated process is developed to ensure timely blood glucose checks and administration of prandial insulin in conjunction with meal delivery.
- Verbal communication of point-of-care blood glucose value results are avoided as much as possible and are NEVER routinely used as the only source of information when determining insulin doses.
- Appropriately label all clinician-prepared syringes of subcutaneous insulin, unless the medication is prepared at the patient's bedside and is immediately administered to the patient

without any break in the process.

- Prior to subcutaneous insulin administration, the practitioner:
 - Confirms that there is an appropriate indication
 - Assesses the patient's most current blood glucose value
 - Assesses the patient for symptoms of hypoglycemia
 - Informs the patient of their most current blood glucose level
 - Informs the patient of their dose, the full name of the product, and the insulin's intended action
- An individual insulin pen is never used for more than one patient.
- Barcode scanning is used to verify that a patient-specific pen is used to administer the correct insulin to the correct patient.
- Prior to transitions of care, a process is in place to ensure that patients will have the necessary prescriptions, supplies, a follow-up care plan, and printed instructions for all prescribed insulin and blood glucose monitoring.
- Patients discharged on insulin are assessed for understanding of their self-management, including:
 - Demonstration of proper dose measurement and self-administration using the same administration device that will be used at home (e.g., vial and syringe, pen, pump)
 - Correct monitoring of blood glucose values
 - The signs and symptoms of hyper- and hypoglycemia and how to respond if these symptoms occur
 - Common types of errors possible with their insulin therapy and how to prevent or detect these errors
 - The importance of regular follow-up with their primary care provider/specialist, including the date of their next appointment
 - Patients who self-administer concentrated U-500 insulin using a vial and syringe are taught to use only a U-500 syringe and communicate their doses in terms of the name and concentration of the insulin and the actual dose in units using only the U-500 syringe

Institute for Safe Medication Practices. (2017). ISMP Guidelines for Optimizing Safe Subcutaneous Insulin Use in Adults. <https://www.ismp.org/sites/default/files/attachments/2017-11/ISMP138-Insulin%20Guideline-051517-2-WEB.pdf>

Lifespan Considerations

Elderly

The elderly are at higher risk for hypoglycemia episodes. The ADA has the following recommendations for elderly patients with diabetes:

- In older adults at increased risk of hypoglycemia, medication classes with low risk of hypoglycemia are preferred.
- Overtreatment of diabetes is common in older adults and should be avoided.
- Deintensification (or simplification) of complex regimens is recommended to reduce the risk of hypoglycemia, if it can be achieved within the individualized A1C target.

American Diabetes Association (2019) 12. Older adults: Standards of Medical Care in Diabetes—2019. *Diabetes Care* 42(S1). <https://doi.org/10.2337/dc19-S012>

Children and Adolescents

Type 1 diabetes is the most common form of diabetes in youth. Unique aspects of care and management of children and adolescents with type 1 diabetes must be considered, such as changes in insulin sensitivity related to physical growth and sexual maturation, ability to provide self-care, supervision in the child care and school environment, neurological vulnerability to hypoglycemia and hyperglycemia in young children, as well as possible adverse neurocognitive effects of diabetic ketoacidosis (DKA). Evidence-based ADA recommendations for glycemic control for children and adolescents include:

- The majority of children and adolescents with type 1 diabetes should be treated with intensive insulin regimens, either via multiple daily injections or continuous subcutaneous insulin infusion.
- All children and adolescents with type 1 diabetes should self-monitor glucose levels multiple times daily (up to 6–10 times/day), including pre-meal, pre-bedtime, and as needed for safety in specific situations such as exercise, driving, or the presence of symptoms of hypoglycemia.
- Continuous glucose monitoring should be considered in all children and adolescents with type 1 diabetes, whether using injections or continuous subcutaneous insulin infusion, as an additional tool to help improve glucose control. Benefits of continuous glucose monitoring correlate with adherence to ongoing use of the device.
- Automated insulin delivery systems appear to improve glycemic control and reduce hypoglycemia in children and should be considered in children with type 1 diabetes.
- An A1C target of <7.5% should be considered in children and adolescents with type 1 diabetes but should be individualized based on the needs and situation of the patient and family.

American Diabetes Association. (2019). 13. Children and adolescents: Standards of Medical Care in Diabetes—2019. *Diabetes Care* 42(S1). <https://doi.org/10.2337/dc19-S013>

There are several different types of insulins that vary in terms of onset, peak, and duration. It is critical for the nurse to be knowledgeable of these differences to help prevent episodes of hypoglycemia due to mismatched administration of insulin with food intake.

Rapid-Acting Insulin

Rapid-acting insulins include insulin lispro (Humalog) and insulin aspart (Novolog) and are also available via inhalation (Afrezza). See Figure 9.11 for an image of Novolog insulin.

"Untitled" from [Pxhere](#) website is licensed under [CC0](#)



Figure 9.11 Novolog insulin

Indications

Rapid-acting insulins are also called prandial insulins because they are administered with meals to mimic the effects of endogenous insulin release when food is eaten. Dosages of rapid-acting insulin are individualized based on carbohydrate intake, premeal glucose levels, and anticipated activity.

Mechanism of Action

Insulins lower blood glucose by stimulating peripheral glucose uptake by skeletal muscle and fat and by inhibiting hepatic glucose production.

Specific Administration Considerations

Humalog-100 (100 units per ml) and Humalog-200 (200 units per ml) are administered subcutaneously; however, only Humalog-100 is administered via continuous subcutaneous injection or intravenously. Humalog-100 can only be mixed with NPH insulin, but Humalog-200 should not be mixed with other insulin. Inspect insulin visually before use. It should appear clear and colorless; do not use if particulate matter or coloration is seen. Humalog-100 is available in vials, KwikPens, and cartridges; Humalog-200 is only available in KwikPens. Administer subcutaneously into the outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. Rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy. Lipodystrophy can be a lump or small dent in the skin that forms when a person performs injections repeatedly in the same spot.

Because of the rapid onset of insulin lispro and insulin aspart and the potential for hypoglycemia, these insulins should be administered within 15 minutes before or right after eating a meal. Peak serum levels are seen 30 to 90 minutes after dosing. Inhaled insulin enters the bloodstream within 1 minute and peaks

in 30-60 minutes. Inhaled insulin is contraindicated in patients with chronic lung disease such as asthma or COPD.

Adverse effects of all insulins include hypoglycemia and hypokalemia. Inhaled insulin has a Black Box Warning for potentially causing acute bronchoconstriction.

Patient Teaching & Education

See ISMP guidelines for patient teaching in the previous section titled “High Risk Medications and Prevention of Errors.”

Short-Acting Insulin

Short-acting insulins include regular insulin with a brand name of Humulin R or Novolin R. A concentrated formulation of Humulin R u-500 is also available. See Figure 9.12 for an image of Humulin R insulin.

"[Humulin R, Insulin, 1987](#)" by National Museum of American History Smithsonian Institution is licensed under [CC BY-NC-ND 2.0](#)



Figure 9.12 Humulin R insulin

Indications

Short-acting insulins are given with meals to mimic the effects of endogenous insulin release when food is eaten. Dosages of short-acting insulin are individualized based on carbohydrate intake, premeal glucose levels, and anticipated activity levels.

Mechanism of Action

The primary activity of insulin is the regulation of glucose metabolism. Insulin lowers blood glucose by stimulating peripheral glucose uptake, especially by skeletal muscle and fat, and by inhibiting hepatic glucose production.

Specific Administration Considerations

Regular insulin is generally administered subcutaneously. It is the only insulin that can be administered intravenously under close supervision of blood glucose and potassium levels. It is available in vials and insulin pens. Inspect insulin visually before use. It should appear clear and colorless; do not use if particulate matter or coloration is seen. Administer subcutaneously into the outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. Rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy. Subcutaneous doses should be administered approximately 30 minutes before meals because this is the typical onset of action. Peak effects occur in 3 hours with a duration of 8 hours. Do not mix with insulin preparations other than NPH.

Humulin R u-500 should only be administered in u-500 insulin syringes to avoid dosage calculation errors.

Adverse effects of insulin include hypoglycemia and hypokalemia.

Patient Teaching & Education

See IMSP guidelines for patient teaching in the previous section entitled “High Risk Medications and Prevention of Errors.”

Intermediate-Acting Insulin

NPH insulin, also known as isophane insulin, is an intermediate-acting insulin. Brand names include Humulin-N or Novolin-N. Mixtures of short- and intermediate-acting insulin include Humulin 70/30 or Novolin 70/30.

Indications

Intermediate insulins are administered once or twice daily to mimic endogenous basal insulin levels.

Mechanism of Action

Insulins lower blood glucose by stimulating peripheral glucose uptake by skeletal muscle and fat and by inhibiting hepatic glucose production.

Specific Administration Considerations

NPH insulin is a white and cloudy suspension. Gently roll or invert vial/pen several times to re-suspend the insulin before administration. It should only be administered subcutaneously. It may be mixed with rapid-acting or short-acting insulins, but those insulins should be drawn into the syringe before the NPH is added. Administer subcutaneously into the outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. Rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy. The onset of action and peak are affected by the site of injection, physical activity level, and other variables but the median peak level occurs in 4 hours. See Figure 9.13 for an image of Novolin-N (a cloudy insulin) that can be mixed with Novolin R (a clear insulin).



Figure 9.13 Comparison of Novolin-N (a cloudy insulin) that can be mixed with Novolin-R (a clear insulin)

Mixed medications such as Humulin 70/30 should be administered subcutaneously approximately 30 minutes before a meal. They are typically dosed twice daily (with each dose intended to cover 2 meals or a meal and a snack).

Unopened vials should be stored in the refrigerator until the expiration date. Opened vials should be labelled with the open date and stored in the refrigerator for up to 28-42 days (depending on the formulation/insulin type) and then discarded. Unopened pens should be stored in the refrigerator until the expiration date. Used pens should be stored at room temperature, but kept away from heat and light, for up to 10-28 days (depending on the formulation/insulin type) and then discarded.

Patient Teaching & Education

See IMSP guidelines for patient teaching in the previous section titled “High Risk Medications and Prevention of Errors.”

Long-Acting Insulin

Insulin glargine (Lantus) and insulin devemir (Levemir) are long-acting insulins given once or twice daily. See Figure 9.14 for an image of a levemir insulin pen.

"[Insulin analog 100 IU-1ml penfill levemir yellow background.jpg](#)" by [Wesalius](#) is licensed under [CC BY 4.0](#)



Figure 9.14 Vial used for Levemir insulin pen

Indications

Long-acting insulins are given once or twice daily. In type 1 diabetics, long-acting insulin should be used concomitantly with rapid- or short-acting insulin at mealtimes.

Mechanism of Action

Insulins lower blood glucose by stimulating peripheral glucose uptake by skeletal muscle and fat and by inhibiting hepatic glucose production.

Specific Administration Considerations

Long-acting insulin has a relatively constant concentration/time profile over 24 hours with no pronounced peak in comparison to NPH insulin. It should only be administered subcutaneously and is available in vials and insulin pens. Inspect insulin visually before use. It should appear clear and colorless; do not use if particulate matter or coloration is seen. Administer subcutaneously into the outer lateral aspect of the upper arm, the abdomen (from below the costal margin to the iliac crest and more than two inches from the umbilicus), the anterior upper thighs, or the buttocks. Rotate injection sites within the same region from one injection to the next to reduce the risk of lipodystrophy.

Patient Teaching & Education

See ISMP guidelines for patient teaching in the previous section titled “High Risk Medications and Prevention of Errors.”

Glucagon

Indications

Glucagon is indicated as a treatment for severe hypoglycemia (low blood sugar), which may occur in patients with diabetes mellitus. Glucagon injection is used for patients who are unable to safely swallow carbohydrates to treat hypoglycemia due to the effects of hypoglycemia or other medical conditions.

Mechanism of Action

Glucagon increases blood glucose concentration during an episode of hypoglycemia. See Figure 9.15 for an image of an emergency glucagon kit.

"[Glucagon emergency rescue kit.JPG](#)" by [mbbradford](#) is licensed under [CC0](#)



Figure 9.15 Emergency glucagon kit

Specific Administration Considerations

Glucagon may be administered subcutaneously, intramuscularly, or intravenously. Peak glucose levels occur within 13-20 minutes of subcutaneous or IM injection.

Patient Teaching & Education

Patients with type 1 diabetes may have less of an increase in blood glucose levels compared with a stable type 2 patient, so a supplementary carbohydrate should be given as soon as possible, especially to a pediatric patient.

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Now let's take a closer look at the medication grid comparing insulins in Table 9.4a.

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Table 9.4a Insulins Medication Grid

Class/Subclass	Prototypes/ Generics	Onset/Peak/ Duration	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Rapid-Acting Insulin	insulin lispro (Humalog)	Onset: 15-30 minutes	Administer within 15 minutes before a meal or	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypoglycemia
	insulin aspart (Novolog)	Peak effect: 1-3 hours	immediately after a meal		Hypokalemia
	inhaled insulin (Afrezza)	Duration: 3 – 5 hours	Afrezza is contraindicated in patients with asthma or COPD		Afrezza can cause acute bronchospasm
Short-Acting Insulin	Humulin R Novolin R	Onset: 30 minutes	Administer 30 minutes before a meal	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypoglycemia Hypokalemia
		Peak effect: 3 hours Duration: 8 hours			
Intermediate- Acting Insulin	Humulin N Novolin N	Onset: 1-2 hours	Administer once or twice daily	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypoglycemia Hypokalemia
		Peak effect: 6 hours (range 2.8-13 hours) Duration: up to 24 hours	Only administer subcutaneously Gently roll or invert vial/pen several times to re-suspend the insulin before administration		
Combination: Intermediate- Acting/Rapid- Acting	Humalog Mix 50/50	Onset: 15-30 minutes	Administer twice daily, 15 minutes before a meal or	Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)	Hypoglycemia Hypokalemia
	Humalog Mix 75/25	Peak effect:	immediately after a meal		
	Novolog Mix 70/ 30	50/50: 1-5 hours Duration: 11-22 hours	Only administer subcutaneously		
	*First number is		Gently roll or		

% intermediate-acting insulin, second number is % rapid-acting

invert vial/pen several times to re-suspend the insulin before administration

Administer twice daily, 30-45 minutes before a meal

Combination: Humulin 70/30
Intermediate-Acting/Short-Acting Novolin 70/30

Onset: 30-90 minutes

Peak effect: 1.5-6.5 hours

Duration: 18-24 hours

Only administer subcutaneously

Gently roll or invert vial/pen several times to re-suspend the insulin before administration

Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)

Hypoglycemia

Hypokalemia

Do not mix with other insulin

Long-Acting Insulin

[insulin glargine](#) (Lantus)

insulin detemir (Levemir)

Onset: 3-4 hours

Peak effect: none

Duration: >24 hours

Administer once daily (sometimes dose is split and administered twice daily)

Only administer subcutaneously

Do not mix with other insulin

Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)

Hypoglycemia

Hypokalemia

May be administered subcutaneously, IM, or IV

Supplementary carbohydrate should be given as soon as

Used to reverse hypoglycemic episode if NPO administration is not appropriate

Hyperglycemia

Hyperglycemic [glucagon](#)

possible,
especially to a
pediatric patient

Used to reverse
hypoglycemic
episode if NPO
administration is
not appropriate

General administration considerations:

- Review orders closely because they may include a standard meal dose, a “sliding scale” dose, and a carb-related dose.
- Always read drug labelling closely as there are several types of dosages and formulations.
- See agency policies and ISMP guidelines for safe administration of insulin.
- When administering with an insulin pen, after inserting the pen count to 5 before removing the needle.

General therapeutic effects:

- Maintain serum blood glucose in normal range and achieve individualized target level of A1C (often 7%)

General side effects:

- Hypoglycemia and hypokalemia

Diabetic Medication: Oral Antihyperglycemics

There are several different classes of oral antihyperglycemic drugs used in conjunction with a healthy diet and exercise for the management of type 2 diabetes. According to the American Diabetes Association, metformin is the preferred initial pharmacologic agent for the treatment of type 2 diabetes. American Diabetes Association. (2019). 9. Pharmacologic Approaches to Glycemic Treatment: Standards of Medical Care in Diabetes—2019. *Diabetes Care* 42(S1). <https://doi.org/10.2337/dc19-S009>

Three of the most commonly used antihyperglycemic classes and prototypes are sulfonylureas (glipizide), biguanide (metformin), and DPP-IV (sitagliptin). The mechanism of action and administration considerations for each of these prototypes are described below.

Glipizide

Mechanism of Action

Glipizide is in the sulfonylurea class of antihyperglycemic medication. The mechanism of action is the stimulation of insulin secretion from the beta cells of pancreatic islet tissue and is thus dependent on

functioning beta cells in the pancreatic islets. Peak plasma concentrations occur 1 to 3 hours after a single oral dose.

Specific Administration Considerations

All sulfonylurea drugs are capable of producing severe hypoglycemia. Hypoglycemia may be difficult to recognize in the elderly and in people who are taking beta-adrenergic blocking drugs. Sulfonylurea medications should be given 30 minutes before a meal due to hypoglycemic effects.

Glipizide is contraindicated in type 1 diabetics or for use of diabetic ketoacidosis; insulin should be used to treat this condition. Treatment of patients with glucose 6-phosphate dehydrogenase (G6PD) deficiency with sulfonylurea agents can lead to hemolytic anemia.

The hypoglycemic action of sulfonylureas may be potentiated by certain drugs such as nonsteroidal anti-inflammatory agents and other drugs that are highly protein bound.

Patient Teaching & Education

Patients should take the medication at the same time each day. It is important that patients understand that the medication helps control episodes of hyperglycemia but does not cure diabetes. Patients should be instructed regarding the signs of hyperglycemia and hypoglycemia. The use of sulfonylureas and alcohol may cause a disulfiram-like reaction.

Metformin

Mechanism of Action

Metformin is in the biguanide class of antihyperglycemics. It decreases hepatic glucose production, decreases intestinal absorption of glucose, and improves insulin sensitivity by increasing peripheral glucose uptake and utilization. Unlike sulfonylureas, metformin does not produce hypoglycemia. See Figure 9.16 for an image of a metformin tablet.

"[Metformin 500mg Tablets.jpg](#)" by [User:Ash](#) is licensed under [CC0](#)



Figure 9.16 Metformin

Specific Administration Considerations

Metformin hydrochloride should be given in divided doses with meals. The therapeutic goal should be to decrease both fasting plasma glucose and glycosylated hemoglobin levels to near normal by using the lowest effective dose of metformin, either when used as monotherapy or in combination with sulfonylurea or insulin.

Common adverse reactions include diarrhea, nausea/vomiting, weakness, flatulence, indigestion, abdominal discomfort, and headache.

Metformin is contraindicated in patients with kidney disease (e.g., serum creatinine levels ≥ 1.5 mg/dL [males] or ≥ 1.4 mg/dL [females]) and should be temporarily discontinued in patients undergoing radiologic studies involving intravascular administration of iodinated contrast materials because use of such products may result in acute alteration of renal function. It is also contraindicated in patients with metabolic acidosis.

Lactic acidosis is a rare, but serious, metabolic complication that can occur due to metformin accumulation during treatment with metformin; when it occurs, it is fatal in approximately 50% of cases. The risk of lactic acidosis increases with the degree of renal dysfunction and the patient's age. Metformin should be promptly withheld in the presence of any condition associated with hypoxemia, dehydration, or sepsis. Because impaired hepatic function may significantly limit the ability to clear lactate, metformin should be avoided in patients with hepatic disease. The onset of lactic acidosis often is subtle and accompanied only by nonspecific symptoms such as malaise, myalgias, respiratory distress, increasing somnolence, and nonspecific abdominal distress.

Patient Teaching & Education

Patients should take the medication at the same time each day. It is important that patients understand that the medication helps control episodes of hyperglycemia but does not cure diabetes. Patients should be instructed regarding the signs of hyperglycemia and hypoglycemia. The patient may be at risk for lactic acidosis and should report chills, low blood pressure, muscle pain, or dyspnea immediately to the healthcare provider. The use of medications like metformin can cause a metallic taste in the mouth.

Sitagliptin

Mechanism of Action

Sitagliptin is an orally-active inhibitor of dipeptidyl peptidase-4 (DPP-4) enzyme that slows the inactivation of incretin hormones involved in the regulation of glucose homeostasis and thus, increases insulin release and decreases glucagon levels in the circulation. See Figure 9.17 for an image of sitagliptin.

"[Januvia sitagliptin.jpg](#)" by [Kimivanil](#) is licensed under [CC BY-SA 4.0](#)

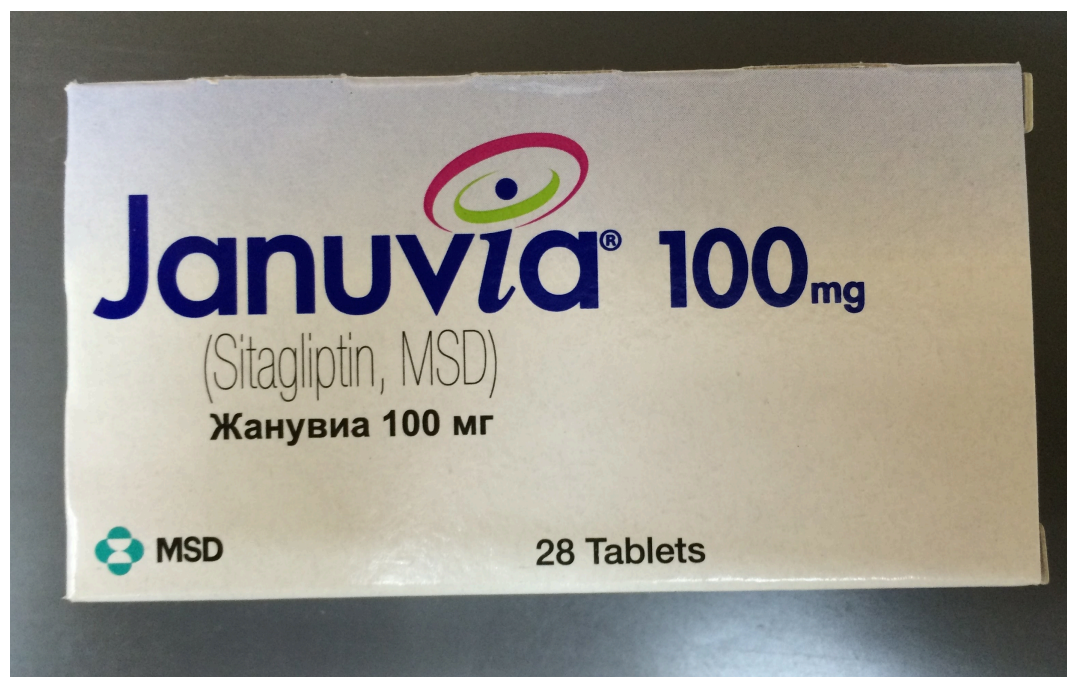


Figure 9.17 Sitagliptin

Specific Administration Considerations

Sitagliptin is taken once daily and can be taken with or without food. It can cause hypoglycemia. Dose adjustment should occur for patients with kidney disease depending on their glomerular filtration rate. Report hypersensitivity reactions, blisters/erosions, headache, or symptoms of pancreatitis, heart failure, severe arthralgia, and upper respiratory infection.

Patient Teaching & Education

Patients should take the medication at the same time each day. It is important that patients understand that the medication helps control episodes of hyperglycemia but does not cure diabetes. Patients should

be instructed regarding the signs of hyperglycemia and hypoglycemia. Patients should stop taking the medication if symptoms of hypersensitivity occur and follow up immediately with their provider to determine the next course of treatment.

Now let's take a closer look at the medication grid comparing oral antihyperglycemics in Table 9.4b. This work is a derivative of [Daily Med](#) by [U.S. National Library of Medicine](#) in the [public domain](#).

Table 9.4b Medication Grid Comparing Oral Antihyperglycemics

Class	Prototype	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Sulfonylureas	glipizide	Time with meals; peak plasma concentrations occur 1 to 3 hours after administration	Reduce fasting blood sugar and glycosylated hemoglobin to near normal	Hypoglycemia; may be potentiated by nonsteroidal anti-inflammatory agents and other drugs that are highly protein bound
Biguanide	metformin	Contraindicated in renal and hepatic disease Should be temporarily discontinued in patients undergoing radiologic studies involving intravascular administration of iodinated contrast materials	Reduce fasting blood sugar and glycosylated hemoglobin to near normal	Stop immediately if signs of lactic acidosis or any condition associated with hypoxemia, dehydration, or sepsis occurs Common adverse effects: diarrhea, nausea/vomiting, weakness, flatulence, indigestion, abdominal discomfort, and headache
DPP-IV inhibitor	sitagliptin	Can be given with or without food	Reduce fasting blood sugar and glycosylated hemoglobin to near norm	Hypoglycemia Report hypersensitivity reactions, blisters/

				erosions, headache, or symptoms of pancreatitis, heart failure, severe arthralgia, or upper respiratory infection
--	--	--	--	--

Critical Thinking Activity 9.4

Image of lightbulb in a circle

A patient with diabetes mellitus type 2 is admitted to the hospital for hip replacement surgery. The nurse reviews the following orders:

Diabetic diet with carb counting

Bedside blood glucose testing before meals and at bedtime with sliding scale Humalog insulin

Sliding scale Humalog insulin based on preprandial glucose level:

- 0-150: No coverage
- 151-175: 2 units
- 176-200: 4 units
- 201-225: 6 units
- 226-250: 8 units
- Over 250: call the provider

Insulin coverage per carbohydrate intake at meals: Humalog 2 units/carb

Metformin 1000 mg twice daily

Humulin-N 20 units at breakfast and at bedtime

Hypoglycemia protocol

1. Explain the difference between type 1 and type 2 diabetes.
2. The patient states that he usually does not take insulin at home. What is the likely rationale for insulin therapy while hospitalized?
3. The patient's blood sugar before breakfast is 223 and he eats 3 carbs at breakfast. What types and amounts of insulin will the nurse administer?
4. The nurse reviews the patient's morning lab results and finds a creatinine of 1.8. She plans to call the provider to discuss the impact of the results on the medications ordered. Which medication may require a dosage adjustment based on these results?
5. When the nurse enters the room around 4 p.m., she discovers that the patient has become irritable and is shaky. The nurse performs a bedside blood glucose and obtains a value of 60. What is the nurse's best response?
6. What is the likely cause of the patient's condition? Explain using the onset and peak actions of the insulin orders.
7. On admission, the patient's A1C level was 10%. What does this lab value indicate?
8. The provider states the discharge plan is to initiate Lantus insulin therapy at home, based on the admitting A1C level. What patient teaching should the nurse plan to provide before discharge?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

9.5 Thyroid Medications

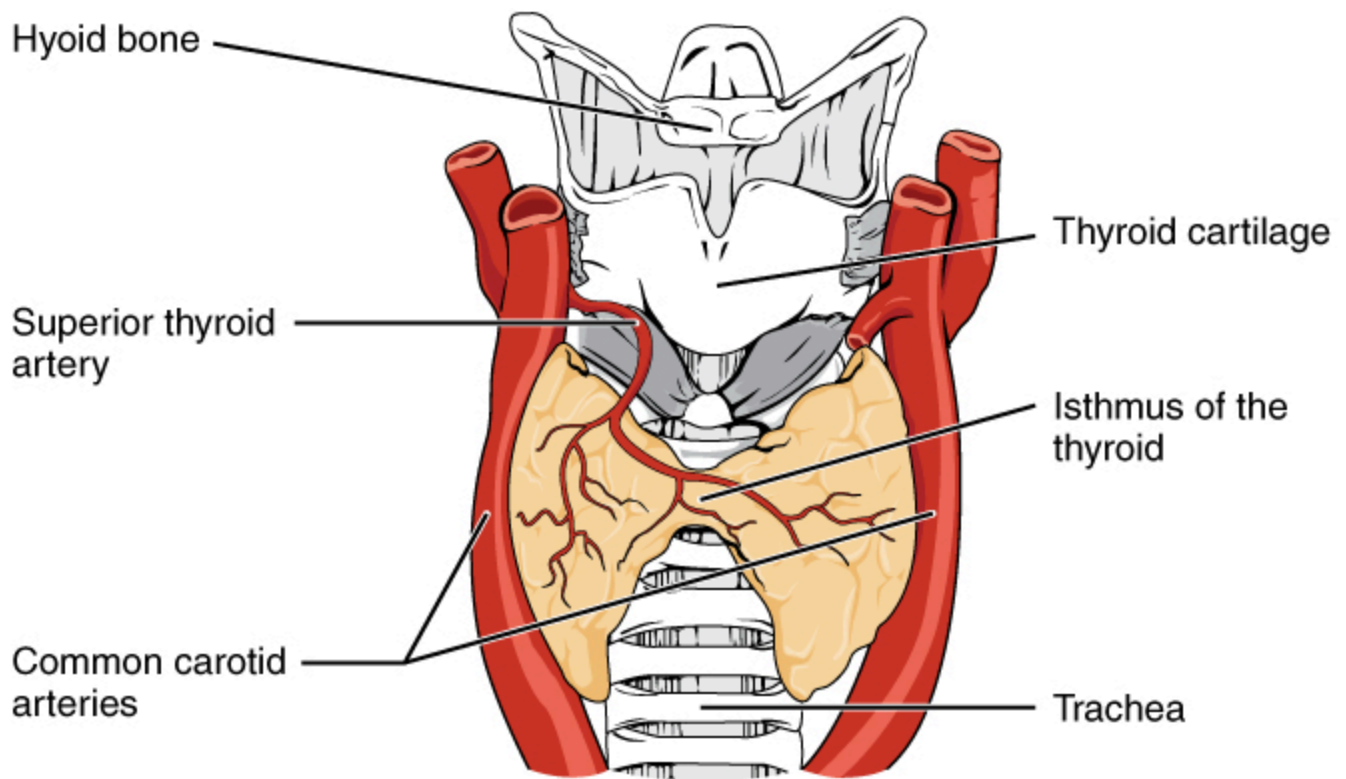
Open Resources for Nursing (Open RN)

Thyroid Basics: A&P Review

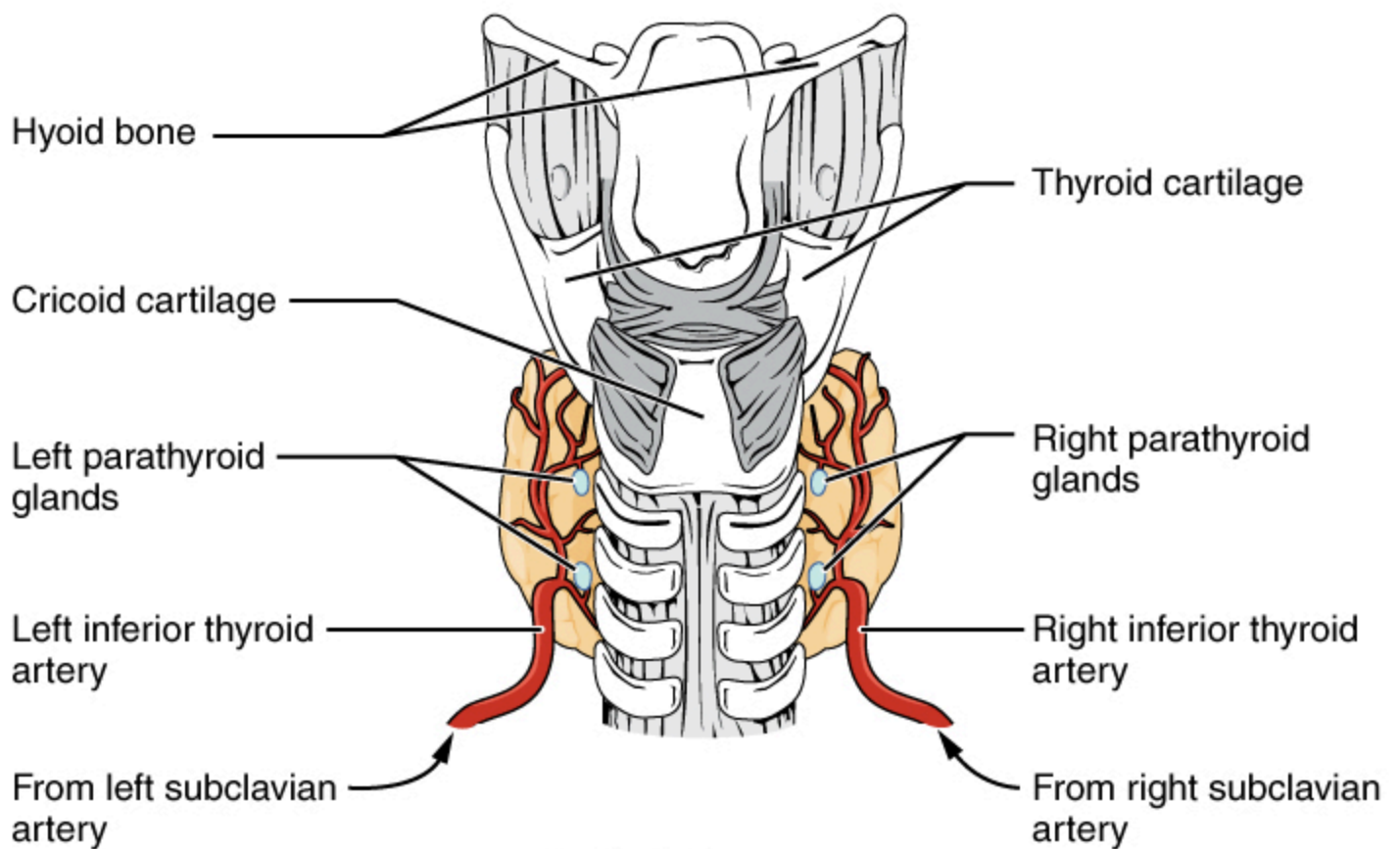
The thyroid is a butterfly-shaped organ located anterior to the trachea, just inferior to the larynx (see Figure 9.18).

"1811 The Thyroid Gland.jpg" by [OpenStax College](https://openstax.org/books/anatomy-and-physiology/pages/17-4-the-thyroid-gland) is licensed under [CC BY 3.0](https://creativecommons.org/licenses/by/3.0/). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-4-the-thyroid-gland>

Each of the thyroid lobes are embedded with parathyroid glands.



a) Anterior view



b) Posterior view

Figure 9.18 The Thyroid Gland

Synthesis and Release of Thyroid Hormones

Thyroid hormone production is dependent on the hormone's essential component: iodine. T3 and T4 hormones are produced when iodine attaches to a glycoprotein called thyroglobulin. The following steps outline the hormone's assembly: Binding of TSH to thyroid receptors causes the cells to actively transport iodide ions across their cell membrane from the bloodstream. As a result, the concentration of iodide ions "trapped" in the thyroid cells is many times higher than the concentration in the bloodstream. The iodide ions undergo oxidation (i.e., their negatively charged electrons are removed) and enzymes link the iodine to tyrosine to produce triiodothyronine (T3), a thyroid hormone with three iodines, or thyroxine (T4), a thyroid hormone with four iodines. These hormones remain in the thyroid follicles until TSH stimulates the release of free T3 and T4 into the bloodstream. In the bloodstream, less than one percent of the circulating T3 and T4 remains unbound. This free T3 and T4 can cross the lipid bilayer of cell membranes and be taken up by cells. The remaining 99 percent of circulating T3 and T4 is bound to specialized transport proteins called thyroxine-binding globulins (TBGs), to albumin, or to other plasma proteins. This "packaging" prevents their free diffusion into body cells. When blood levels of T3 and T4 begin to decline, bound T3 and T4 are released from these plasma proteins and readily cross the membrane of target cells. T3 is more potent than T4, and many cells convert T4 to T3 through the removal of an iodine atom.

Regulation of Thyroid Hormone Synthesis

A negative feedback loop controls the regulation of thyroid hormone levels. As shown in Figure 9.19, "1813 A Classic Negative Feedback Loop.jpg" by OpenStax College is licensed under [CC BY 4.0](https://creativecommons.org/licenses/by/4.0/). Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-4-the-thyroid-gland>

low blood levels of T3 and T4 stimulate the release of thyrotropin-releasing hormone (TRH) from the hypothalamus, which triggers secretion of TSH from the anterior pituitary. In turn, TSH stimulates the thyroid gland to secrete T3 and T4. The levels of TRH, TSH, T3, and T4 are regulated by a negative feedback system in which increasing levels of T3 and T4 decrease the production and secretion of TSH.

1) Metabolic rate and/or T_3 and T_4 concentration in blood...

Low?

- Hypothalamus releases TRH. This triggers TSH release by the pituitary.



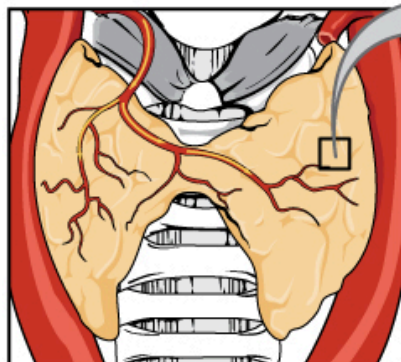
High?

- Hypothalamus stops TRH release
- Anterior pituitary stops TSH release

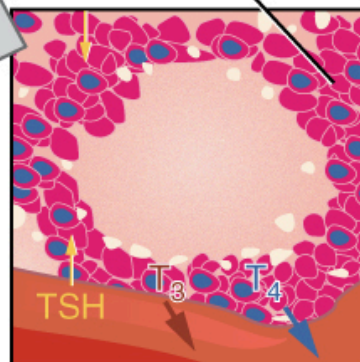
~~TRH~~ ~~TSH~~

4) Negative

- Elevated inhibits



Thyroid follicle cells



T_3 release

T_4 release

2) Effects of TSH release:

- Triggers release of T_3 and T_4 by thyroid follicle cells

3) Effects

- Increased rate of
- Rise in (calorific)

Figure 9.19 Negative Feedback Loop. A negative feedback loop controls the regulation of thyroid hormone levels

Functions of Thyroid Hormones

The thyroid hormones T3 and T4 are often referred to as metabolic hormones because their levels influence the body's basal metabolic rate, which is the amount of energy used by the body at rest. When T3 and T4 bind to intracellular receptors located on the mitochondria, they cause an increase in nutrient breakdown and the use of oxygen to produce ATP. In addition, T3 and T4 initiate the transcription of genes involved in glucose oxidation. Although these mechanisms prompt cells to produce more ATP, the process is inefficient, and an abnormally increased level of heat is released as a byproduct of these reactions. This calorogenic effect (calor- = "heat") raises body temperature.

Adequate levels of thyroid hormones are also required for protein synthesis and for fetal and childhood tissue development and growth. They are especially critical for normal development of the nervous system both in utero and in early childhood, and they continue to support neurological function in adults. Thyroid hormones also have a complex interrelationship with reproductive hormones, and deficiencies can influence libido, fertility, and other aspects of reproductive function. Finally, thyroid hormones increase the body's sensitivity to catecholamines (epinephrine and norepinephrine) from the adrenal medulla by upregulation of receptors in the blood vessels. When levels of T3 and T4 hormones are excessive, this effect accelerates the heart rate, strengthens the heartbeat, and increases blood pressure. Because thyroid hormones regulate metabolism, heat production, protein synthesis, and many other body functions, thyroid disorders can have severe and widespread consequences.

Disorders of the Thyroid Gland: Iodine Deficiency, Hypothyroidism, and Hyperthyroidism

As discussed above, dietary iodine is required for the synthesis of T3 and T4. For much of the world's population, foods do not provide adequate levels of iodine because the amount varies according to the level in the soil in which the food was grown, as well as the irrigation and fertilizers used. Marine fish and shrimp tend to have high levels because they concentrate iodine from seawater, but many people in landlocked regions lack access to seafood. Thus, the primary source of dietary iodine in many countries is iodized salt. Fortification of salt with iodine began in the United States in 1924, and international efforts to iodize salt in the world's poorest nations continue today.

Dietary iodine deficiency can result in the impaired ability to synthesize T3 and T4, leading to a variety of severe disorders. When T3 and T4 cannot be produced, TSH is secreted in increasing amounts. As a result of this hyperstimulation, thyroglobulin and colloid accumulate in the thyroid gland and increase the overall size of the thyroid gland, a condition called a **goiter** (see Figure 9.20

["Goitre.jpg"](#) by [Almazi](#) is licensed under [CC0](#)

). A goiter is only a visible indication of the deficiency. Other disorders related to iodine deficiency include impaired growth and development, decreased fertility, and prenatal and infant death. Moreover, iodine deficiency is the primary cause of preventable mental retardation worldwide. Neonatal hypothyroidism (cretinism) is characterized by cognitive deficits, short stature, and sometimes deafness and muteness in children and adults born to mothers who were iodine-deficient during pregnancy.



Figure 9.20 Goiter

In areas of the world with access to iodized salt, dietary deficiency is rare. Instead, inflammation of the thyroid gland is a common cause of **hypothyroidism**, or low blood levels of thyroid hormones. Hypothyroidism is a disorder characterized by a low metabolic rate, weight gain, cold extremities, constipation, reduced libido, menstrual irregularities, and reduced mental activity, and requires long-term thyroid hormone replacement therapy. In contrast, **hyperthyroidism**—an abnormally elevated blood level of thyroid hormones—is often caused by a pituitary or thyroid tumor. In Graves' disease, the hyperthyroid state results from an autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland. Hyperthyroidism can lead to an increased metabolic rate, excessive body heat and sweating, diarrhea, weight loss, tremors, and increased heart rate. The person's eyes may bulge (called exophthalmos) as antibodies produce inflammation in the soft tissues of the orbits. The person may also develop a goiter. Hyperthyroidism is often treated by thyroid surgery or with radioactive iodine (RAI) therapy. Patients are asked to follow radiation precautions after RAI treatment to limit radiation exposure to others, especially pregnant women and young children, such as sleeping in a separate bed and flushing the toilet 2-3 times after use. The RAI treatment may take up to several months to have its effect. The end result of thyroid surgery or RAI treatment is often hypothyroidism, which is treated by thyroid hormone replacement therapy.

American Thyroid Association. (2019). *Radioactive iodine*. <https://www.thyroid.org/radioactive-iodine/>

Calcitonin

The thyroid gland also secretes another hormone called calcitonin. Calcitonin is released in response to elevated blood calcium levels. It decreases blood calcium concentrations by:

- Inhibiting the activity of osteoclasts (bone cells that breakdown bone matrix and release calcium into the circulation)
- Decreasing calcium absorption in the intestines
- Increasing calcium loss in the urine

Pharmaceutical preparations of calcitonin are prescribed to reduce osteoclast activity in people with osteoporosis. Osteoporosis is a disease that can be caused by glucocorticoids.

Calcium is critical for many other biological processes. It is a second messenger in many signaling pathways and is essential for muscle contraction, nerve impulse transmission, and blood clotting. Given these roles, it is not surprising that blood calcium levels are tightly regulated by the endocrine system. The parathyroid glands are primarily involved in calcium regulation.

Calcium Regulation: Parathyroid Glands

The parathyroid glands are four tiny, round structures usually embedded in the posterior surface of the thyroid gland (see Figure 9.21).

"1814 The Parathyroid Glands.jpg" by OpenStax College is licensed under CC BY 3.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-5-the-parathyroid-glands>

The primary function of the parathyroid glands is to regulate blood calcium levels by producing and secreting **parathyroid hormone (PTH)** in response to low blood calcium levels.

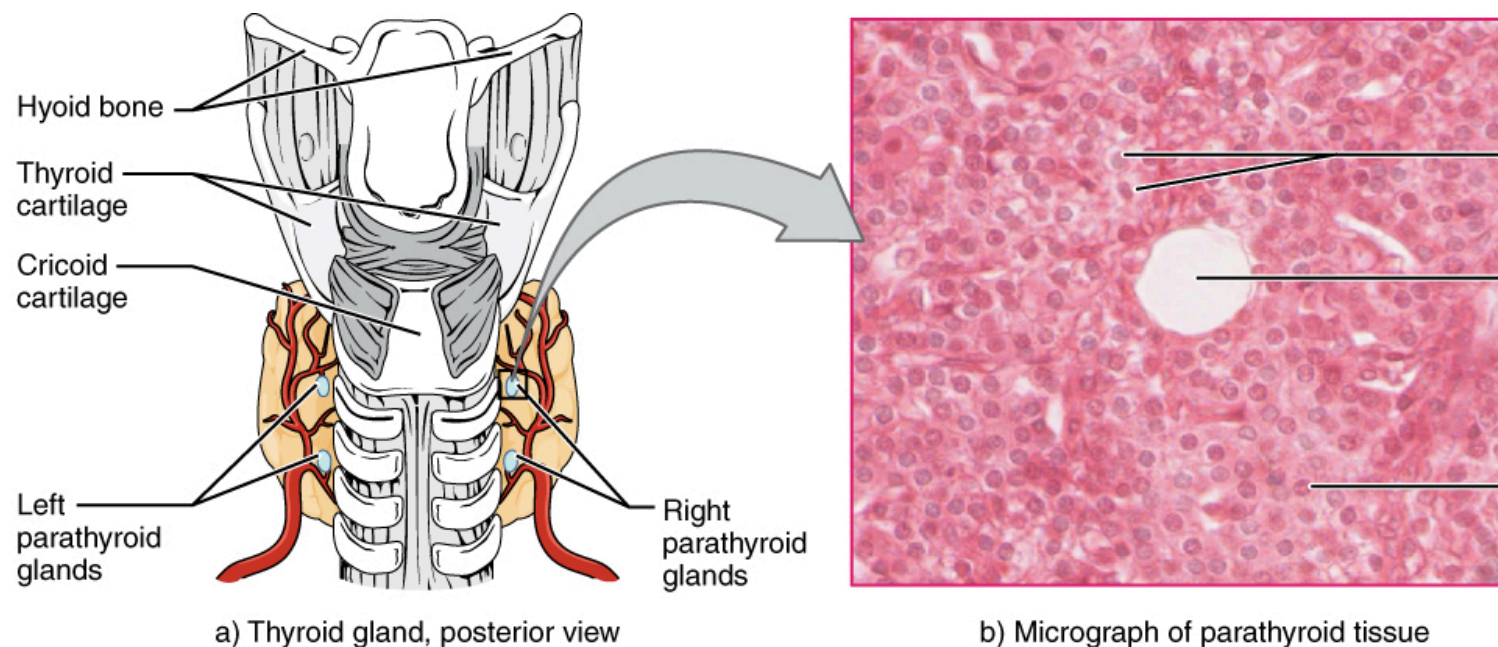
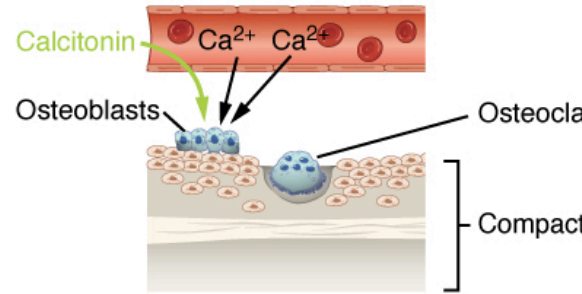


Figure 9.21 The Parathyroid Glands

PTH secretion causes the release of calcium from the bones by stimulating osteoclasts that degrade bone and then release calcium into the bloodstream. PTH also inhibits osteoblasts, the cells involved in bone deposition, thereby keeping calcium in the blood. PTH also causes increased reabsorption of calcium (and magnesium) in the kidney and initiates the production of the steroid hormone calcitriol, which is the active form of vitamin D3. Calcitriol then stimulates increased absorption of dietary calcium by the intestines. A negative feedback loop regulates the levels of PTH, with rising blood calcium levels inhibiting further release of PTH. (See Figure 9.22 for an illustration of the role of parathyroid hormone in maintaining blood calcium homeostasis.)

"1817 The Role of Parathyroid Hormone in Maintaining Blood Calcium Homeostasis.jpg" by OpenStax is licensed under CC BY 4.0. Access for free at <https://openstax.org/books/anatomy-and-physiology/pages/17-5-the-parathyroid-glands>

1) Blood calcium concentration drops

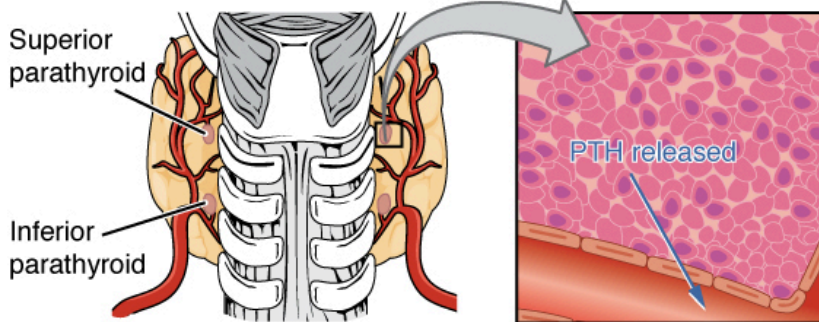


6) Effects of calcitonin on bone:

- Stimulates osteoblasts
- Inhibits osteoclasts
- Calcium is removed from blood and used to

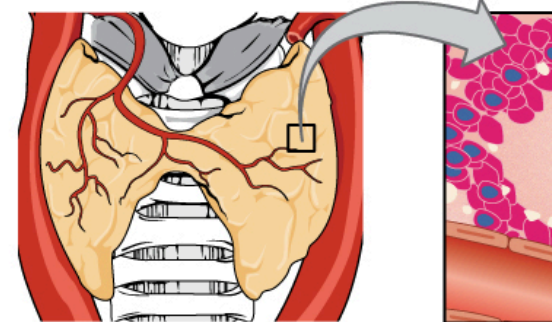
2) Release of PTH:

- Chief cells of the parathyroid gland release parathyroid hormone (PTH).



5) Calcitonin release:

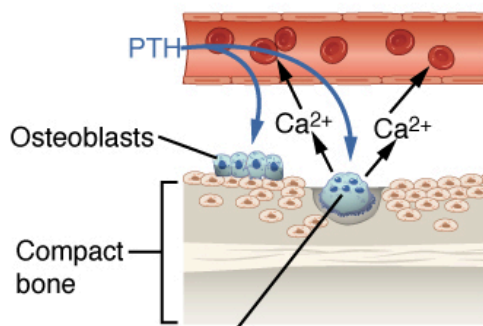
- High concentrations of calcium stimulate parathyroid cells in the thyroid to release calcitonin.



4) Blood calcium levels increase

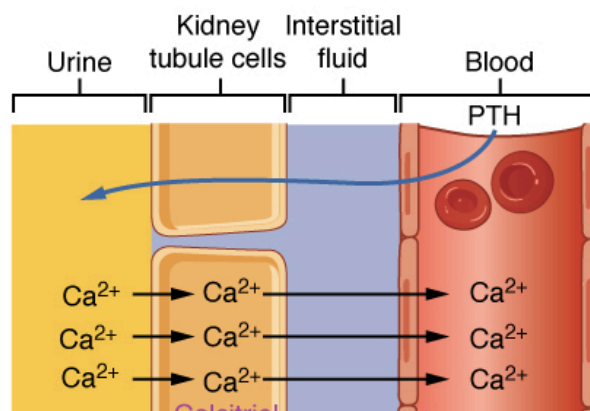
3a) Effects of PTH on bone:

- Inhibits osteoblasts
- Stimulates osteoclasts
- Bone is broken down, releasing calcium ions into bloodstream



3b) Effects of PTH on kidneys:

- PTH stimulates kidney tubule cells to recover waste calcium from the urine.
- PTH stimulates kidney tubule cells to release calcitriol.



3c) Effects of calcitriol:

- Stimulates intestinal calcium absorption

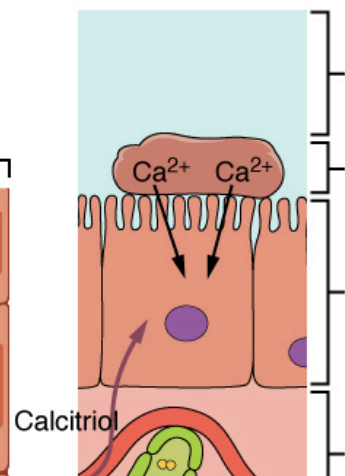


Figure 9.22 Parathyroid Hormone in Maintaining Blood Calcium Homeostasis

Disorders of the Parathyroid Glands

Abnormally high activity of the parathyroid gland can cause **hyperparathyroidism**, a disorder caused by an overproduction of PTH that results in excessive degradation of bone and elevated blood levels of calcium, also called hypercalcemia. Hyperparathyroidism can thus significantly decrease bone density, which can lead to spontaneous fractures or deformities. As blood calcium levels rise, cell membrane permeability to sodium is also decreased, and thus the responsiveness of the nervous system is reduced. At the same time, calcium deposits may collect in the body's tissues and organs, impairing their functioning.

In contrast, abnormally low blood calcium levels may be caused by parathyroid hormone deficiency, called **hypoparathyroidism**, which may develop following injury or surgery involving the thyroid gland. Low blood calcium increases membrane permeability to sodium, thus increasing the responsiveness of the nervous system, resulting in muscle twitching, cramping, spasms, or convulsions. Severe deficits can paralyze muscles, including those involved in breathing, and can be fatal.

Nursing Considerations

Assessment

When administering thyroid replacement medications, the nurse should plan to monitor TSH levels before and during therapy for effectiveness. Drug interactions may occur with several other medications, so review drug labeling information carefully before administering.

Implementation

Levothyroxine should be administered consistently every morning 30-60 minutes before a meal.

Evaluation

Elevated levels of thyroid hormone can cause cardiac dysrhythmias; immediately report any symptoms of tachycardia, chest pain, or palpitations to the provider.

Thyroid and Osteoporosis Medication Classes

Thyroid Replacement Medication

Indications

Levothyroxine is a thyroid replacement drug used to treat hypothyroidism. See Figure 9.23 for an image of levothyroxine.

"[Levothyroxine 25mcg Tablets.jpg](#)" by [User:Ash](#) is licensed under [CC0](#)



Figure 9.23 Levothyroxine

Mechanism of Action

Oral levothyroxine sodium is a synthetic T4 hormone that exerts the same physiologic effect as endogenous T4, thereby maintaining normal T4 levels when a deficiency is present.

Specific Administration Considerations

Levothyroxine tablets should be taken with a full glass of water as the tablet may rapidly disintegrate. It should be administered as a single daily dose, on an empty stomach, one-half to one hour before breakfast, and at least 4 hours before or after drugs known to interfere with levothyroxine absorption.

Levothyroxine is contraindicated for patients with hyperthyroidism and adrenal insufficiency until the condition is corrected. Many patients who undergo treatment for hyperthyroidism may develop hypothyroidism. Overtreatment with levothyroxine may cause symptoms of hyperthyroidism with increased heart rate, cardiac wall thickness, and cardiac contractility that may precipitate angina or arrhythmias, particularly in patients with cardiovascular disease and in elderly patients. Levothyroxine therapy in this population should be initiated at lower doses. If cardiac symptoms develop or worsen, the nurse should withhold the medication, contact the health care provider, and anticipate a lower dose prescribed or the medication to be withheld for one week then restarted at a lower dose.

Addition of levothyroxine therapy in patients with diabetes mellitus may worsen glycemic control and result in the need for higher dosages of antidiabetic medication. Carefully monitor glycemic control, especially when thyroid therapy is started, changed, or discontinued.

Levothyroxine increases the response to oral anticoagulant therapy. Therefore, a decrease in the dose of anticoagulant may be warranted with correction of the hypothyroid state or when the levothyroxine dose

is increased. Closely monitor INR results and anticipate dosage adjustments.

Levothyroxine can affect, or be affected by, several other medications, so carefully read drug label information when therapy is initiated.

Pregnancy: There are risks to the mother and fetus associated with untreated hypothyroidism in pregnancy. Because TSH levels may increase during pregnancy, TSH should be monitored and levothyroxine dosage may require adjustment during pregnancy.

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Patient Teaching & Education

Patients should take thyroid replacement medications at the same time each day. Patients should be aware that thyroid replacement medications do not cure hypothyroidism and therapy is lifelong. Patients should notify their healthcare provider if they experience signs of headache, diarrhea, sweating, or heat intolerance. Medications should be spaced four hours apart from medications like antacid, iron, or calcium supplements. Patients will be followed closely by their healthcare provider regarding their response to medication therapy and serum thyroid levels will be taken.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Antithyroid Medication

Indications

Propylthiouracil (PTU) is an antithyroid medication used to treat hyperthyroidism or to ameliorate symptoms of hyperthyroidism in preparation for thyroidectomy or radioactive iodine therapy.

Mechanism of Action

Propylthiouracil inhibits the synthesis of thyroid hormones.

Specific Administration Considerations

Propylthiouracil is administered orally. The total daily dosage is usually given in 3 equal doses at approximately 8-hour intervals. Propylthiouracil can cause hypothyroidism necessitating routine monitoring of TSH and free T4 levels, with adjustments in dosing to maintain a euthyroid state.

Liver injury resulting in liver failure, liver transplantation, or death has been reported. Patients should be instructed to report any symptoms of hepatic dysfunction (anorexia, pruritus, and right upper quadrant pain), particularly in the first six months of therapy.

Agranulocytosis is a potentially life-threatening side effect of propylthiouracil therapy. Agranulocytosis typically occurs within the first 3 months of therapy. Patients should be instructed to immediately report any symptoms suggestive of agranulocytosis, such as fever or sore throat.

Cases of vasculitis resulting in severe complications and death have been reported in patients receiving propylthiouracil therapy. If vasculitis is suspected, discontinue therapy and initiate appropriate intervention.

Pregnancy: Propylthiouracil crosses the placenta and can cause fetal liver failure, goiter, and cretinism if

administered to a pregnant woman.

Patient Teaching & Education

Patients should take the medication as directed at regular dosing intervals. They should monitor their weight 2-3 times per week. Additionally, patients should be advised that medications may cause drowsiness, and they should report any signs of sore throat, fever, headache, jaundice, bleeding, or bruising.

Osteoporosis Medication: Calcitonin

Indications

Calcitonin is used to treat osteoporosis.

Mechanism of Action

Calcitonin is a calcitonin receptor agonist. Calcitonin is released by the thyroid gland. It acts primarily on bone and also has effects on the kidneys and the gastrointestinal tract.

Specific Administration Considerations

Calcitonin is administered via nasal spray with one spray in one side of the nose daily. See Figure 9.24 for an image of calcitonin nasal spray.

"Nasal Spray" by NIAID is licensed under [CC BY 2.0](#)

The nasal spray pump should be primed before the first administration. Unopened calcitonin can be stored in the refrigerator until opened, but should not be refrigerated between doses. Opened bottles stored at room temperature should be discarded after 30 days of initial dose.

Adverse effects include serious hypersensitivity reactions (bronchospasm, swelling of the tongue or throat, anaphylaxis and anaphylactic shock), hypocalcemia, nasal mucosa adverse events, and malignancy.

Pregnancy: Calcitonin should not be used during pregnancy.

Patient Teaching & Education

Patients should be advised to take medications as directed. They should report any signs of hypercalcemia or an allergic response. Patients should receive instruction on the process of self-injection. They should also be advised that they may experience flushing and warmth following injection. Post-menopausal women should adhere to a diet high in calcium and vitamin D, and should be educated regarding the importance of exercise for reversing bone loss.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>



Figure 9.24 Administration of Calcitonin

Indications

Alendronate is used for the prevention and treatment of osteoporosis in postmenopausal women, to increase bone mass in men with osteoporosis, and for glucocorticoid-induced osteoporosis.

Mechanism of Action

Alendronate is a bisphosphonate that inhibits osteoclast-mediated bone resorption. By preventing the breakdown of bone and enhancing the formation of new bone, alendronate assists in reversing bone loss and decreases the risk of fractures.

Specific Administration Considerations

Check dosages carefully because some formulations are administered daily, whereas others are administered one weekly. Alendronate should be taken upon arising for the day, but should be administered at least one-half hour before the first food, beverage, or medication of the day with plain water only. Other beverages (including mineral water), food, and some medications are likely to reduce the absorption of alendronate. Patients should not lie down for at least 30 minutes and until after their first food of the day. Patients may also require calcium and vitamin D supplementation, especially if concurrently taking glucocorticoids.

Alendronate is contraindicated in the following conditions: pregnancy, hypocalcemia, the inability to sit or stand for 30 minutes after swallowing, esophageal abnormalities that delay emptying, and patients at risk for aspiration. Alendronate is not recommended for patients with kidney disease with creatinine clearance less than 35 mL/min.

Discontinue alendronate if severe musculoskeletal pain occurs. A bone mineral density measurement should be made at the initiation of therapy and repeated after 6 to 12 months of combined alendronate and glucocorticoid treatment.

Patient Teaching & Education

Patients should take medication as directed at the same time each day, first thing in the morning. Patients should remain upright after they take medication for 30 minutes to minimize stomach and esophageal irritation. Patients should eat a balanced diet and may seek advice from the healthcare provider regarding supplementation with calcium and vitamin D. Patients should participate in regular exercise to help increase bone strength.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Now let's take a closer look at the medication grid comparing thyroid and osteoporosis medications in Table 9.5.

This work is a derivative of [Daily Med](#) by [U.S. National Library of Medicine](#) in the [public domain](#).

Medication grids are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below. Detailed information on a specific medication can be found for free at Daily Med at <https://dailymed.nlm.nih.gov/dailymed/index.cfm>. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also hyperlinked directly to a Daily Med page.

Table 9.5. Medication Grid Comparing Thyroid and Osteoporosis Medications

Class	Prototype/ Generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Thyroid replacement	levothyroxine	Take levothyroxine sodium tablets with a full glass of water as the tablet may rapidly disintegrate Administer levothyroxine as a single daily dose, on an empty stomach, one-half to one hour before breakfast Administer	Increases T4 levels in hypothyroidism	Hypersensitivity reactions Cardiac dysrhythmias

		levothyroxine at least 4 hours before or after drugs known to interfere with levothyroxine sodium tablets absorption Anticipate lower dosages in elderly patients with pre-existing cardiac disease May interact with several medications so read drug label thoroughly on initial administration for potential effects		
Antithyroid	propylthiouracil (PTU)	Usually administered every 8 hours May cause hypothyroidism so TSH and T4 levels should be monitored If a patient becomes pregnant, immediately notify health care provider because it can cause fetal harm	Inhibit production of T4	Hypothyroidism Liver failure Agranulocytosis Vasculitis Fetal harm
Calcium	calcitonin	Administer nasal	Treats osteoporosis	Serious

regulator		spray with one spray in one side of the nose daily Contraindicated during pregnancy Discard unrefrigerated bottle after 30 days of opening May store unopened bottles in refrigerator until expiration date		hypersensitivity reactions (bronchospasm, swelling of the tongue or throat, anaphylaxis, and anaphylactic shock) Hypocalcemia Nasal mucosa adverse effects Malignancy
Bisphosphonates	alendronate	Administered upon arising and at least one-half hour before the first food, beverage, or medication of the day with plain water only The patient should sit or stand for 30 minutes after administration Contraindicated in pregnancy, hypocalcemia, and kidney disease Concurrent calcium and vitamin D supplements may be required	Enhances bone mineral density in osteoporosis	Upper GI tract adverse events Severe musculoskeletal pain Risk of osteonecrosis of the jaw

Critical Thinking Activity 9.5

Image of lightbulb in a circle

A patient has been diagnosed with hypothyroidism and receives a prescription for levothyroxine.

What patient education should the nurse provide regarding taking this medication?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

9.6 Module Learning Activities

Open Resources for Nursing (Open RN)

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=1791#h5p-25>

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=1791#h5p-23>

IX: Glossary

Open Resources for Nursing (Open RN)

A1C: A lab test used to assess long-term blood glucose levels over 3 months. The general A1C target level is less than 7%.

Adrenal cortex: A component of the hypothalamic-pituitary-adrenal (HPA) axis that produces the steroid hormones important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation.

Adrenal medulla: Neuroendocrine tissue composed of postganglionic sympathetic nervous system

(SNS) neurons that are stimulated by the autonomic nervous system to secrete hormones epinephrine and norepinephrine.

Aldosterone: A mineralocorticoid released by the adrenal cortex that controls fluid and electrolyte balance through the regulation of sodium and potassium.

Antidiuretic hormone (ADH): ADH is released by the posterior pituitary in response to stimuli from osmoreceptors indicating high blood osmolarity. Its effect is to cause increased water reabsorption by the kidneys. As more water is reabsorbed by the kidneys, the greater the amount of water that is returned to the blood, thus causing a decrease in blood osmolarity. ADH is also known as vasopressin because, in very high concentrations, it causes constriction of blood vessels, which increases blood pressure by increasing peripheral resistance.

Basal insulin: Long-acting (insulin glargine or insulin detemir) or intermediate-acting (NPH) insulin.

Basal Metabolic Rate: The amount of energy used by the body at rest.

Blood osmolarity: The concentration of solutes (such as sodium and glucose) in the blood.

Diabetes insipidus (DI): A disease characterized by underproduction of ADH that causes chronic dehydration.

Endocrine gland: Gland that secretes hormones that target other organs.

Exocrine gland: Gland that secretes digestive enzymes.

General adaptation syndrome (GAS): The pattern in which the body responds in different ways to stress: the alarm reaction (otherwise known as the fight-or-flight response,) the stage of resistance, and the stage of exhaustion.

Glycolysis: Stimulated by insulin, the metabolism of glucose for generation of ATP.

Goiter: A visible enlargement of the thyroid gland when there is hyperstimulation of TSH due to deficient levels of T3 and T4 hormones in the bloodstream or an autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland, causing hyperthyroidism.

Hormones: Chemical signals sent by the endocrine organs and transported via the bloodstream throughout the body where they bind to receptors on target cells and induce a characteristic response.

Humoral stimuli: Changes in blood levels of non-hormone chemicals that cause an endocrine gland to release or inhibit a hormone to maintain homeostasis. For example, high blood sugar causes the pancreas to release insulin.

Hyperglycemia: Elevated blood glucose levels.

Hyperparathyroidism: A disorder caused by an overproduction of PTH that results in excessive calcium resorption from bone, causing significantly decreased bone density and spontaneous fractures, decreased responsiveness of the nervous system, and calcium deposits in the body's tissues and organs, impairing their functioning.

Hyperthyroidism: Abnormally elevated blood level of thyroid hormones T3 and T4, often caused by a pituitary tumor, thyroid tumor, or autoimmune reaction in which antibodies overstimulate the follicle cells of the thyroid gland.

Hypoglycemia: A blood glucose level below 70 mg/dL; severe hypoglycemia refers to a blood glucose level below 40.

Hypoparathyroidism: Abnormally low blood calcium levels caused by parathyroid hormone deficiency, which may develop following thyroid surgery. Low blood calcium can cause muscle twitching, cramping, spasms, or convulsions; severe deficits can paralyze muscles, including those involved in breathing, and can be fatal.

Hypothalamic-pituitary-adrenal (HPA) axis: The hypothalamus stimulates the release of ACTH from the pituitary, which then stimulates the adrenal cortex to produce the hormone cortisol and steroid hormones important for the regulation of the stress response, blood pressure and blood volume, nutrient uptake and storage, fluid and electrolyte balance, and inflammation.

Hypothalamus–pituitary complex: The “command center” of the endocrine system that secretes several hormones that directly produce responses in target tissues, as well as hormones that regulate the synthesis and secretion of hormones of other glands. In addition, the hypothalamus–pituitary complex coordinates the messages of the endocrine and nervous systems.

Hypothyroidism: Abnormally low blood levels of thyroid hormones T3 and T4 in the bloodstream.

Insulin: A hormone that facilitates the uptake of glucose into skeletal and adipose body cells.

Mineralocorticoids: Hormones released by the adrenal cortex that regulate body minerals, especially sodium and potassium, that are essential for fluid and electrolyte balance. Aldosterone is the major mineralocorticoid.

Negative feedback loop: Characterized by the inhibition of further secretion of a hormone in response to adequate levels of that hormone.

Neural stimuli: Released in response to stimuli from the nervous system. For example, the activation of the release of epinephrine and norepinephrine in the fight-or-flight response is stimulated by the sympathetic nervous system.

Osmoreceptors: Specialized cells within the hypothalamus that are sensitive to the concentration of sodium ions and other solutes in the bloodstream.

Parathyroid hormone (PTH): The hormone released by parathyroid glands and is involved in the regulation of blood calcium levels.

Prandial insulins: During or relating to the eating of food.

Tropic hormones: Hormones that turn on or off the function of other endocrine glands, including ACTH, FSH, LH, and TSH.

Type 1 diabetes: An autoimmune disease that affects the beta cells of the pancreas so they do not

produce insulin; thus, synthetic insulin must be administered by injection or infusion.

Type 2 diabetes: A condition where the body's cells become resistant to the effects of insulin. Over time, the beta cells become exhausted and if blood glucose levels cannot be controlled through a healthy diet and exercise, then oral diabetic medication must be implemented and eventually insulin administration may be required.

X

Analgesic and Musculoskeletal

10.1 Analgesics and Musculoskeletal Introduction

Open Resources for Nursing (Open RN)

Learning Objectives

- Cite the classifications and actions of analgesics
- Cite the classifications and actions of musculoskeletal system drugs
- Give examples of when, how, and to whom analgesics and musculoskeletal system drugs may be administered
- Identify the side effects and special considerations associated with analgesics
- Identify the side effects and special considerations associated with musculoskeletal system drugs
- Identify the considerations and implications of using analgesics across the life span
- Identify the considerations and implications of using musculoskeletal system medications across the life span
- Apply evidence-based concepts when using the nursing process

Complaints of pain are one of the most common reasons individuals seek out medical care. The pain signal indicates that something in the body is not quite right! Whether it be a headache, a broken bone, labor pain, chest pain, or other condition, pain assessment and treatment will become an important part of your daily work.

As a nurse, you will care for patients experiencing various types of pain manifestations and responses. It will be important for you to understand the various pharmacological and non-pharmacological treatment methods available for your patients.

10.2 Review of Basic Concepts

Open Resources for Nursing (Open RN)

Before we learn about the medications that are used to treat analgesic and musculoskeletal conditions in

our patients, we must first review the physiology of pain and the anatomy of the musculoskeletal system.

Analgesic System

Physiology of Pain

Pain occurs when there is tissue damage in the body. Tissue damage activates pain receptors of peripheral nerves. **Nociceptors**, the nerve endings that respond to painful stimuli, are located in arterial walls, joint surfaces, muscle fascia, periosteum, skin, and soft tissue. Nociceptors are barely present in most internal organs.

. Frandsen, G. & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice (11th ed.)*. (pg. 305, 310, 952-953, 959-960). Wolters Kluwer.

The cause of tissue damage may be physical (e.g., heat, cold, pressure, stretch, spasm, and ischemia) or chemical (pain-producing substances are released into the extracellular fluid surrounding the nerve fibers that carry the pain signal). These pain-producing substances activate pain receptors, increase the sensitivity of pain receptors, or stimulate the release of inflammatory substances (e.g., **prostaglandins**).

. Frandsen, G. & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice (11th ed.)*. (pg. 305, 310, 952-953, 959-960). Wolters Kluwer.

For a person to feel pain, the signal from the nociceptors in peripheral tissues must be transmitted to the spinal cord and then to the hypothalamus and cerebral cortex of the brain. The signal is transmitted to the brain by two types of nerve cells (A-delta and C fibers). The dorsal horn of the spinal cord is the relay station for information from these fibers. In the brain, the thalamus is the relay station for incoming sensory stimuli, including pain. From the thalamus, the pain messages are relayed to the cerebral cortex where they are perceived.

. Frandsen, G. & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice (11th ed.)*. (pg. 305, 310, 952-953, 959-960). Wolters Kluwer.

See Figure 10.1 for an illustration of how the pain signal is transmitted from peripheral tissues to the spinal cord and then to the brain.

"[Sketch colored final.png](#)" by [Bettina Guebeli](#) is licensed under [CC BY-SA 4.0](#)

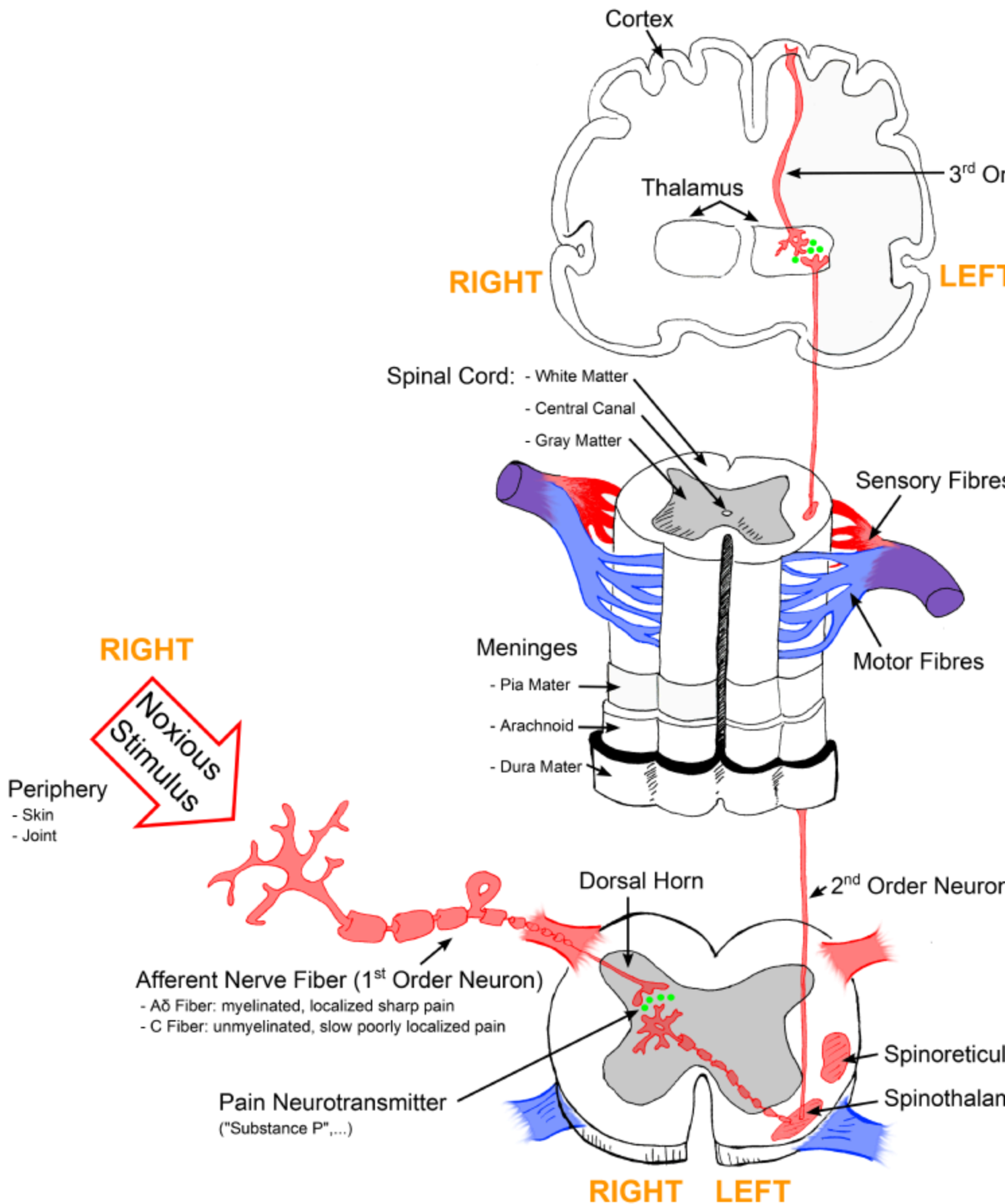


Figure 10.1 The Transmission of Pain from Peripheral Tissues to the Brain

Endogenous Analgesia

The CNS has its own endogenous analgesia system for relieving pain. The CNS suppresses pain signals from peripheral nerves. Opioid peptides interact with opioid receptors to inhibit perception and transmission of pain signals. These opioid peptides are endorphins, enkephalins, and dynorphins.

. Frandsen, G. & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice (11th ed.)*. (pg. 305, 310, 952-953, 959-960). Wolters Kluwer.

See the video below for more information about how pain relievers work.

How Do Pain Relievers Work? by George Zaidan

Ted-Ed. (2012, June 26). How Do Pain Relievers Work? - George Zaidan [Video]. YouTube. <https://youtu.be/9mcuIc5O-DE>

One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://wtcs.pressbooks.pub/pharmacology/?p=2448#oembed-1>

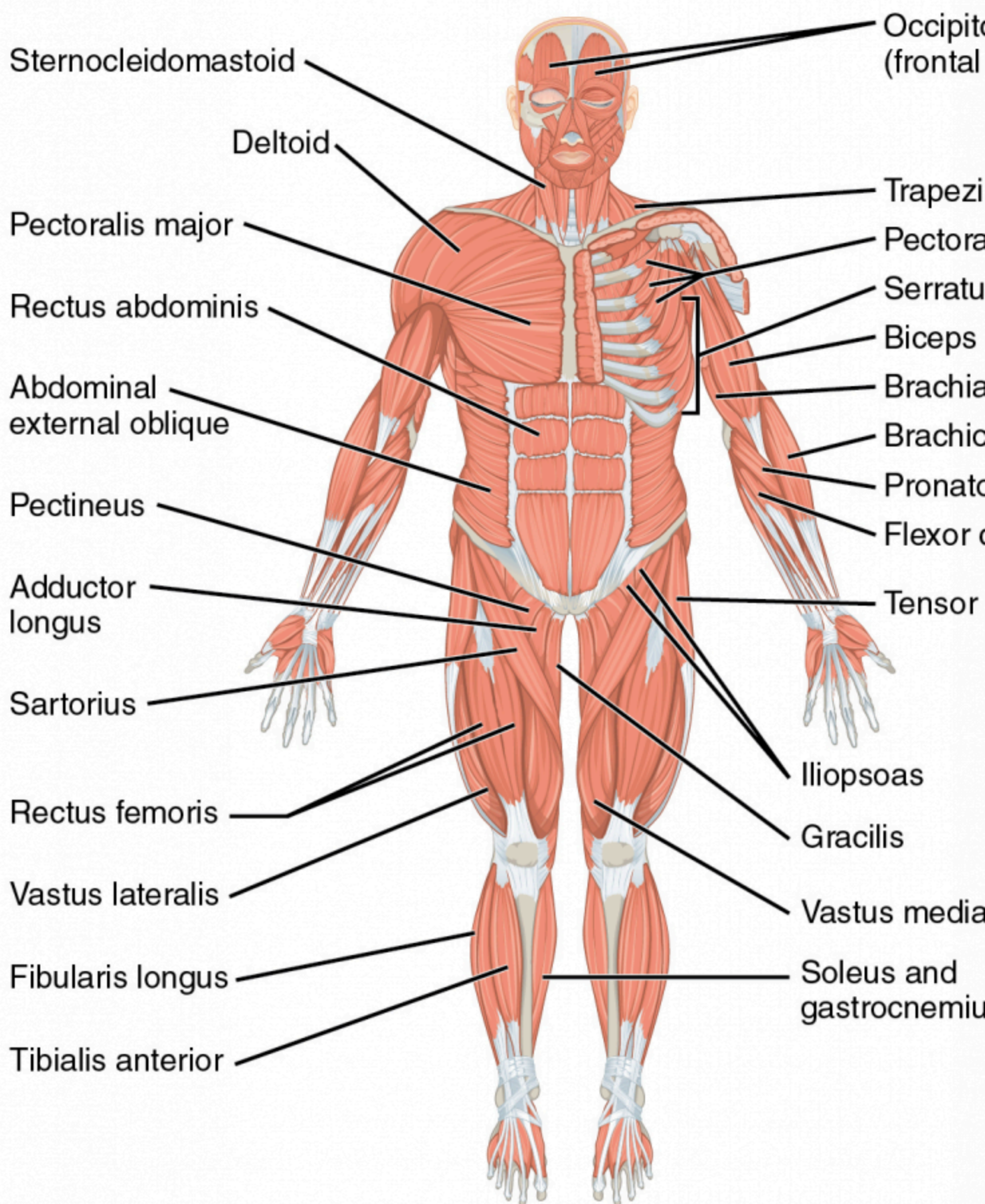
Musculoskeletal System

In the musculoskeletal system, the muscular and skeletal systems work together to support and move the body. The bones of the skeletal system serve to protect the body's organs, support the weight of the body, and give the body shape. The muscles of the muscular system attach to these bones, pulling on them to allow for movement of the body.

Khan Academy. (n.d.). *The musculoskeletal system review*. <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-musculoskeletal-system/a/hs-the-musculoskeletal-system-review>

See Figure 10.2 for an illustration of the musculoskeletal system.

This image is a derivative of "[1105 Anterior and Posterior Views of Muscles.jpg](#)" by [CFCE](#) is licensed under [CC BY 4.0](#)



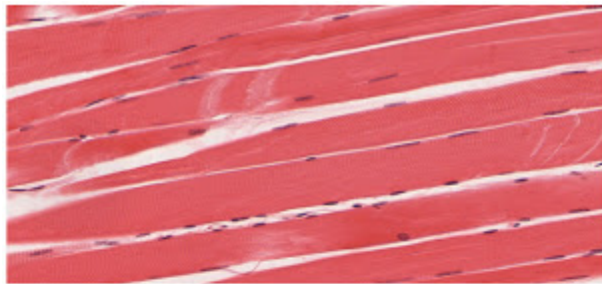
Major muscles of the body.
Right side: superficial: left side:

Figure 10.2 The Musculoskeletal System

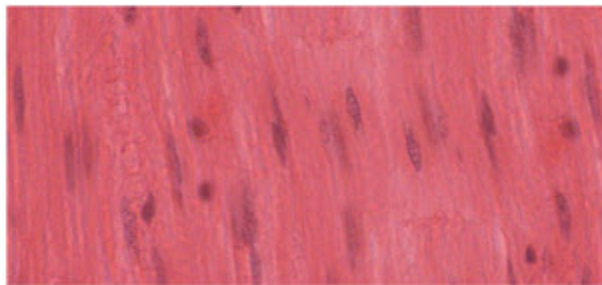
Muscles

The body contains three types of muscle tissue: skeletal muscle, smooth muscle, and cardiac muscle. See Figure 10.3 for images of different types of muscle.

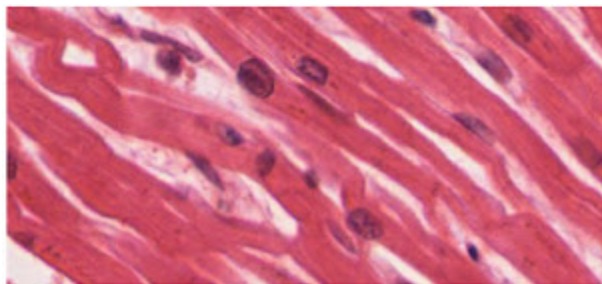
"414 Skeletal Smooth Cardiac.jpg" by [OpenStax College](#) is licensed under [CC BY 4.0](#)



(a)



(b)



(c)

Figure 10.3 (a) Skeletal muscle; (b) Smooth muscle; (c) Cardiac muscle

Skeletal muscle is voluntary and striated. These are the muscles that attach to bones and control conscious movement. Smooth muscle is involuntary and non-striated. It is found in the hollow organs of the body, such as the stomach, intestines, and around blood vessels. Cardiac muscle is involuntary and striated. It is found only in the heart and is specialized to help pump blood throughout the body.

Khan Academy. (n.d.). *The musculoskeletal system review*. <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-musculoskeletal-system/a/hs-the-musculoskeletal-system-review>

When a muscle fiber receives a signal from the nervous system, myosin filaments are stimulated, pulling actin filaments closer together. This shortens sarcomeres within a fiber, causing it to contract.

Khan Academy. (n.d.). *The musculoskeletal system review*. <https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-musculoskeletal-system/a/hs-the-musculoskeletal-system-review>

10.3 Conditions and Diseases

Open Resources for Nursing (Open RN)

Several conditions can cause pain or inflammation that require the use of analgesics or musculoskeletal medication. Common disorders are briefly reviewed below.

Acute Pain

Acute pain usually comes on suddenly and is caused by something specific. It is sharp in quality. Acute pain usually does not last longer than six months. It goes away when there is no longer an underlying cause for the pain. Causes of acute pain include:

- Surgery
- Broken bones
- Dental work
- Burns or cuts
- Labor and childbirth

After acute pain goes away, a person can go on with life as usual.

Cleveland Clinic. (2017, January 26). *Acute v. chronic pain*. <https://my.clevelandclinic.org/health/articles/12051-acute-vs-chronic-pain>

Chronic Pain

Chronic pain is pain that is ongoing and usually lasts longer than six months. This type of pain can continue even after the injury or illness that caused it has healed or gone away. Pain signals remain active in the nervous system for weeks, months, or years. Some people suffer chronic pain even when there is no past injury or apparent body damage. Chronic pain is linked to conditions including:

- Headache
- Arthritis
- Cancer
- Nerve pain
- Back pain
- Fibromyalgia pain

People who have chronic pain can have physical effects that are stressful on the body. These include tense muscles, limited ability to move around, a lack of energy, and appetite changes. Emotional effects of chronic pain include depression, anger, anxiety, and fear of reinjury. Such a fear might limit a person's ability to return to their regular work or leisure activities.

Cleveland Clinic. (2017, January 26). *Acute v. chronic pain*. <https://my.clevelandclinic.org/health/articles/12051-acute-vs-chronic-pain>

Fibromyalgia

Fibromyalgia is a condition that causes pain all over the body (also referred to as widespread pain), sleep problems, fatigue, and often emotional and mental distress. People with fibromyalgia may be more sensitive to pain than people without fibromyalgia. This is called abnormal pain perception processing. Fibromyalgia affects about 4 million US adults, about 2% of the adult population. The cause of fibromyalgia is not known, but it can be effectively treated and managed.

Centers for Disease Control and Prevention. (2017, October 11). *Arthritis, Fibromyalgia*. <https://www.cdc.gov/arthritis/basics/fibromyalgia.htm>

The most common symptoms of fibromyalgia are the following:

- Pain and stiffness all over the body
- Fatigue and tiredness
- Depression and anxiety
- Sleep problems
- Problems with thinking, memory, and concentration
- Headaches, including migraines

Other symptoms may include:

- Tingling or numbness in hands and feet
- Pain in the face or jaw, including disorders of the jaw known as temporomandibular joint syndrome (TMJ)
- Digestive problems, such as abdominal pain, bloating, constipation, and even irritable bowel syndrome (IBS)

Known risk factors include:

- Age. Fibromyalgia can affect people of all ages, including children. However, most people are diagnosed during middle age
- Lupus or Rheumatoid Arthritis. Patients diagnosed with lupus or rheumatoid arthritis (RA) are more likely to develop fibromyalgia

Other factors that have been weakly associated with onset of fibromyalgia include:

- Sex. Women are twice as likely to have fibromyalgia as men
- Stressful or traumatic events, such as car accidents or post-traumatic stress disorder (PTSD)
- Repetitive injuries. Injury from repetitive stress on a joint, such as frequent knee bending
- Illness (such as viral infections)
- Family history
- Obesity

Doctors usually diagnose fibromyalgia using the patient's history, physical examination, X-rays, and blood work.

Centers for Disease Control and Prevention. (2017, October 11). *Arthritis, Fibromyalgia*. <https://www.cdc.gov/arthritis/basics/fibromyalgia.htm>

Gout

Gout is a common form of inflammatory arthritis that is very painful. It usually affects one joint at a time (often the big toe joint). There are times when symptoms get worse, known as flares, and times when there are no symptoms, known as remission. Repeated bouts of gout can lead to gouty arthritis, a worsening form of arthritis.

There is no cure for gout, but you can effectively treat and manage the condition with medication and self-management strategies.

Gout flares start suddenly and can last days or weeks. These flares are followed by long periods of remission (weeks, months, or years) without symptoms before another flare begins. Along with the big toe, joints commonly affected are the lesser toe joints, the ankle, and the knee.

Centers for Disease Control and Prevention. (2019, January 28). *Arthritis, Gout*. <https://www.cdc.gov/arthritis/basics/gout.html>

Symptoms in the affected joint(s) may include:

- Pain, usually intense
- Swelling
- Redness
- Heat

Gout is caused by a condition known as hyperuricemia, where there is too much uric acid in the body. The body makes uric acid when it breaks down purines, which are found in your body and the foods you eat. When there is too much uric acid in the body, uric acid crystals (monosodium urate) can build up in joints, fluids, and tissues within the body. Hyperuricemia does not always cause gout, and hyperuricemia without gout symptoms does not need to be treated.

The following make it more likely that you will develop hyperuricemia, which causes gout:

- Being male
- Being obese

Having certain health conditions can also increase your chances of developing hyperuricemia. These conditions include the following:

- Congestive heart failure
- Hypertension (high blood pressure)
- Insulin resistance
- Metabolic syndrome
- Diabetes
- Poor kidney function

Additional factors may increase your chances of developing hyperuricemia:

- Using certain medications, such as diuretics (water pills)
- Drinking alcohol. The risk of gout is greater as alcohol intake increases
- Eating or drinking food and drinks high in fructose (a type of sugar)

- Having a diet high in purines, which the body breaks down into uric acid. Purine-rich foods include red meat, organ meat, and some kinds of seafood, such as anchovies, sardines, mussels, scallops, trout, and tuna.

A medical doctor diagnoses gout by assessing your symptoms and the results of your physical examination, X-rays, and lab tests. Gout can only be diagnosed during a flare when a joint is hot, swollen, and painful and when a lab test finds uric acid crystals in the affected joint.

Centers for Disease Control and Prevention. (2019, January 28). *Arthritis, Gout*. <https://www.cdc.gov/arthritis/basics/gout.html>

Muscle Spasm

Spasms of skeletal muscles are most common and are often due to overuse and muscle fatigue, dehydration, and electrolyte abnormalities. The spasm occurs abruptly, is painful, and is usually short-lived. It may be relieved by gently stretching the muscle.

Wedro, B. (2019, July 18). *Muscle spasms*. https://www.medicinenet.com/muscle_spasms/article.htm.

Diseases such as multiple sclerosis can also cause chronic muscle spasms.

Multiple Sclerosis

Multiple sclerosis (MS) involves an **immune-mediated disease process** in which an abnormal response of the body's immune system is directed against the central nervous system (CNS). The CNS is made up of the brain, spinal cord, and optic nerves.

Within the CNS, the immune system causes inflammation that damages myelin (the fatty substance that surrounds and insulates the nerve fibers), as well as the nerve fibers themselves and the specialized cells that make myelin. When myelin or nerve fibers are damaged or destroyed in MS, messages within the CNS are altered or stopped completely. Damage to areas of the CNS may produce a variety of neurological symptoms that will vary among people with MS in type and severity. The damaged areas develop scar tissue that gives the disease its name – multiple areas of scarring or multiple sclerosis. The cause of MS is not known, but it is believed to involve genetic susceptibility, abnormalities in the immune system, and environmental factors that combine to make MS symptoms variable and unpredictable. No two people have exactly the same symptoms, and each person's symptoms can change or fluctuate over time. One person might experience only one or two of the possible symptoms, while another person might experience several symptoms of the disease.

Symptoms include:

- Fatigue
- Numbness or tingling
- Weakness
- Dizziness or vertigo
- Walking difficulties
- **Muscle spasticity**
- Blurred vision

At this time, there are no symptoms, physical findings, or laboratory tests that can, by themselves, determine if a person has MS. Several strategies are used to determine if a person meets the long-

established criteria for a diagnosis of MS and to rule out other possible causes of whatever symptoms they are experiencing. These strategies include a careful medical history, a neurologic exam, and various tests including magnetic resonance imaging (MRI), spinal fluid analysis, and blood tests.

National Multiple Sclerosis Society. (2018, March 8). *What is MS?* [Video]. YouTube. All Rights Reserved. https://youtu.be/geQP_zYS-6s

Myasthenia Gravis

Myasthenia Gravis (MG) is an autoimmune disease that occurs when the immune system attacks the body's own tissues. In MG, the attack interrupts the connection between nerve and muscle called the neuromuscular junction. Myasthenia gravis is characterized by autoantibodies against the acetylcholine receptor or against a receptor-associated protein called muscle-specific tyrosine kinase. You can read more details about acetylcholine receptors in the “Autonomic Nervous System” chapter.

MG causes weakness in muscles that control the eyes, face, neck, and limbs. Symptoms include partial paralysis of eye movements, double vision and droopy eyelids, as well as weakness and fatigue in neck and jaws and problems chewing, swallowing, and holding up the head. MG is treatable with drugs that suppress the immune system or boost the signals between nerve and muscle.

Muscular Dystrophy Association. (n.d.). *Myasthenia gravis*. <https://www.mda.org/disease/myasthenia-gravis>

The group of drugs used to control MG are called acetylcholinesterase (ACh) inhibitors. They inhibit the action of the enzyme acetylcholinesterase so that more acetylcholine (ACh) is available to activate cholinergic receptors and promote muscle contraction. ACh inhibitors are classified as parasympathomimetics. Pyridostigmine is an example of an ACh inhibitor.

Overdosing with ACh inhibitors can cause a complication called cholinergic crisis, which is an acute exacerbation of symptoms. A cholinergic crisis usually occurs 30-60 minutes after taking cholinergic medication with severe muscle weakness that can lead to respiratory paralysis and death.

McCustion, L., Vuljoin-DiMaggio, K., Winton, M, & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 268-270, 324, 332. Elsevier.

10.4 Nursing Process for Analgesics and Musculoskeletal Medications

Open Resources for Nursing (Open RN)

Now that we have reviewed basic concepts related to pain and several disorders requiring analgesic or musculoskeletal medication, let's consider the nursing process and how it applies to these types of medications.

Assessment

Although there are numerous details to consider when administering medications, it is important to always first think about what you are giving and why?

First, let's think of why?

Analgesic medications are given to alleviate pain. An important piece of your nursing assessment should be to assess the patient's pain level. The patient's pain level is what the patient says it is. This is accomplished by using a pain scale. Always find out the acceptable pain level for your patient. See Figure 10.5

"Mnemonics for Pain Assessment" by Julie Teeter is licensed under [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/) for common nursing mnemonics for pain assessment.

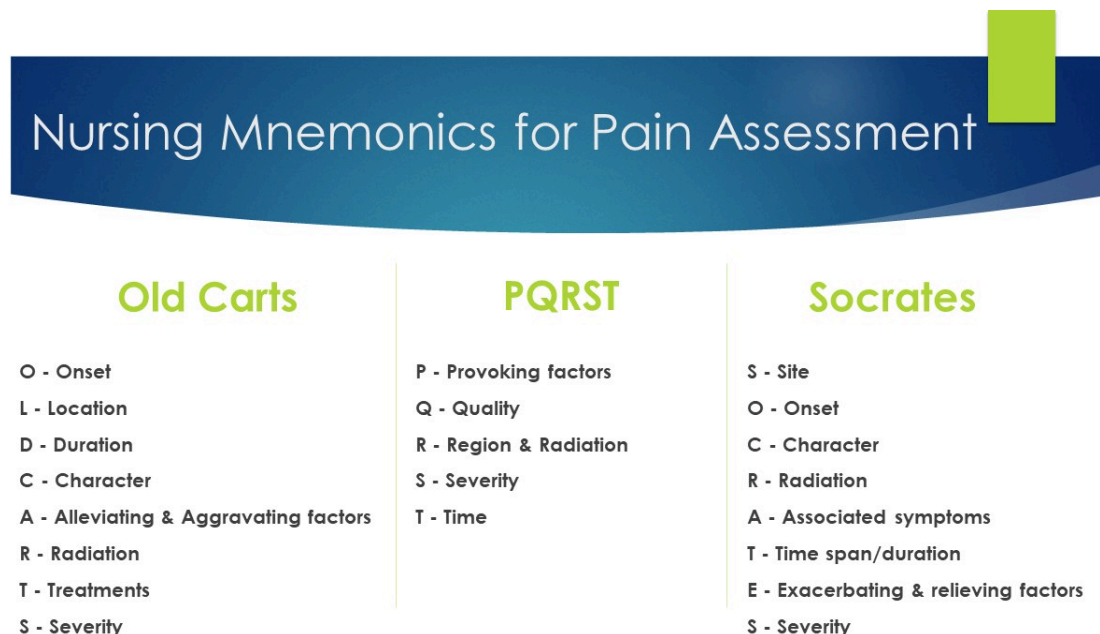


Figure 10.5 Mnemonics for Pain Assessment

Visual pain scales have been developed as a tool of communication about pain with children through patients at end of life. See Figure 10.6

Wong-Baker FACES Foundation (2020). Wong-Baker FACES® Pain Rating Scale. Retrieved [2020] with permission from <http://www.WongBakerFACES.org>

for the FACES Pain Rating Scale. To use this scale, use the following evidence-based instructions. Explain to the patient that each face represents a person who has no pain (hurt), some, or a lot of pain. "Face 0 doesn't hurt at all. Face 2 hurts just a little. Face 4 hurts a little more. Face 6 hurts even more. Face 8 hurts a whole lot. Face 10 hurts as much as you can imagine, although you don't have to be crying to have this worst pain." Ask the person to choose the face that best represents the pain they are feeling.

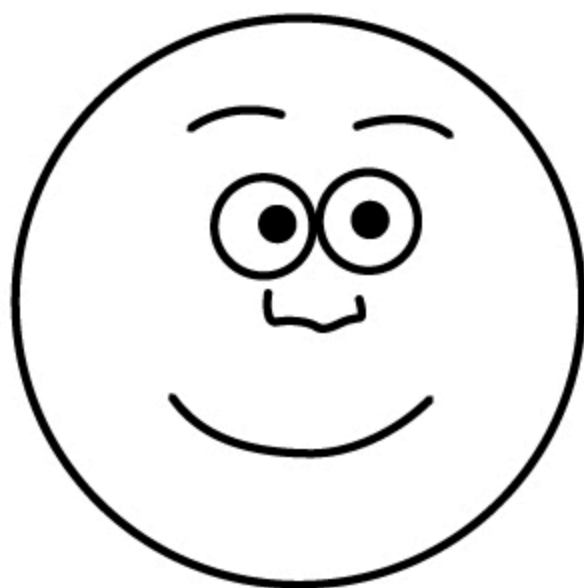
Additional baseline information to collect prior to administration of any analgesic or musculoskeletal medication includes any history of allergy or previous adverse response.

Won



0

**No
Hurt**



2

**Hurts
Little Bit**

©198

Used with permission. Origin

Figure 10.6. The Wong-Baker FACES Pain Rating Scale. Used with permission from <http://www.WongBakerFACES.org>.

Implementation of Interventions

With the administration of analgesic or musculoskeletal medications, it is important to always perform the five rights (right patient, medication, dose, route, and time) and to check for allergies prior to administration. Prior to administration, it is important to consider the best route of administration for this patient at this particular time. For example, if the patient is nauseated and vomiting, then an oral route may not be effective. See Figure 10.7 for a list of common opioid medications ranging from use for moderate to severe pain.

Vallerand, A. & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

When administering opioid medications, it is important to remember that these medications are controlled substances with special regulations regarding storage, auditing counts, and disposal or wasting of medication. See more information about controlled substances in the “Legal/Ethical” chapter.

Common Opioid Analgesics

Generic Name	Trade Name(s)	Route	
codeine/acetaminophen	Tylenol #3	PO	30 mg/300 mg
		Transdermal	12 mcg/hr
fentanyl	Duragesic	IM	0.5-1 mcg/kg
	Sublimaze	IV	0.5-1 mcg/kg
	Lortab	PO	5 mg/300 mg
hydrocodone/acetaminophen	Norco	PO	10 mg/300 mg
	Vicodin	PO	
		PO	4-8 mg
hydromorphone	Dilaudid	Rectal	3 mg
		SubQ, IM & IV	1.5 mg (1/2 tab)
		PO & Rectal	30 mg (1 tab)
morphine	Duramorph, MS Contin, Oramorph SR, & Roxanol-T	SubQ, IM, & IV	4-10 mg
oxycodone	Oxy IR, Oxycontin & Oxy-FAST	PO	5 mg-10 mg
oxycodone/acetaminophen	Percocet & Roxicet	PO	5 mg/325 mg

Figure 10.7 Table of Common Opioid Analgesics

A general rule of thumb when administering analgesics is to use the least invasive medication that is anticipated to treat the level of pain reported by the patient. The WHO ladder was originally developed for selection of analgesics for patients with cancer but illustrates the concept that pain control should be based on the level indicated by the patient. See Figure 10.8

World Health Organization. Cancer pain relief. 2nd ed. Geneva: WHO; 1996.

for an image of the WHO ladder. For example, if a patient reports a pain level of “2,” then it is appropriate to start at the lowest rung of the ladder and administer a non-opioid. However, it may be clinically indicated to start at “Level 3” on the WHO ladder for patients who present with severe, difficult pain.

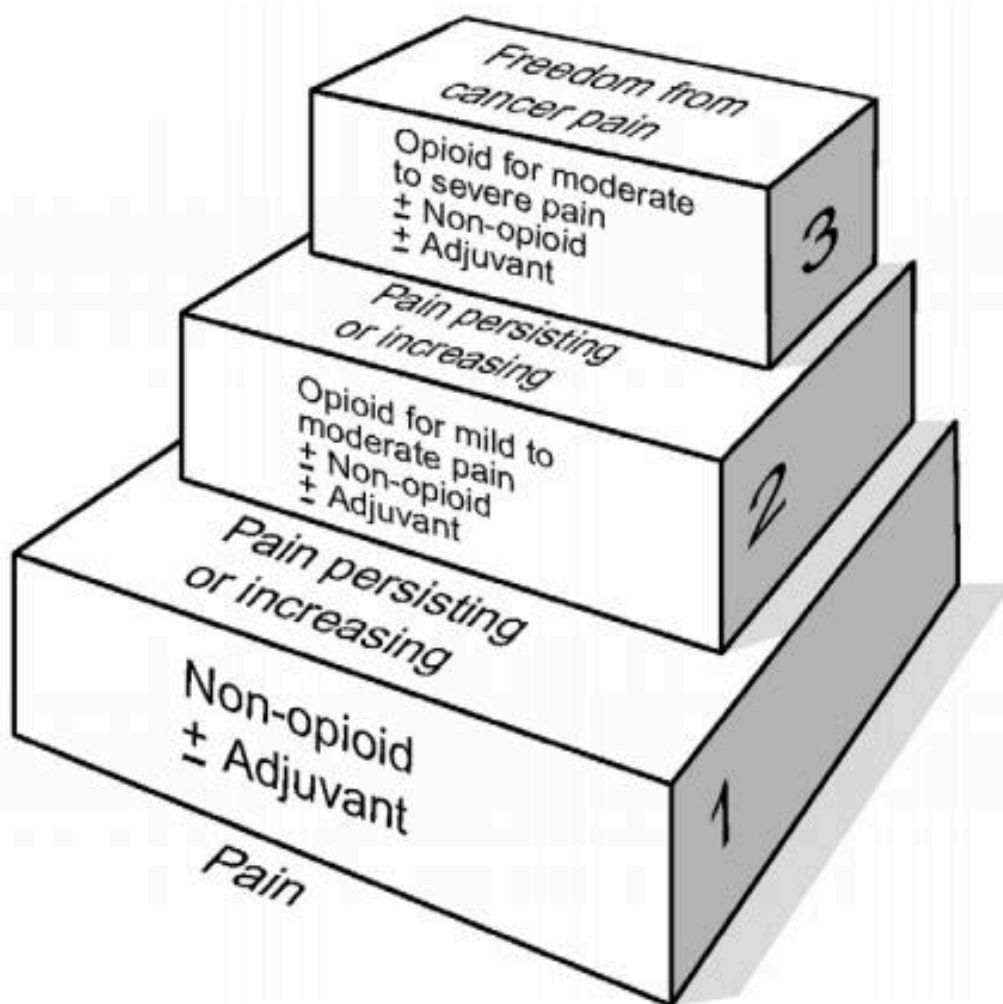


Figure 10.8 The WHO Pain Ladder. This diagram below shows the step-wise approach to cancer pain management recommended by the World Health Organization (WHO)

It is important to anticipate any common side effects and the expected outcome of the medication, as well as considerations regarding what to teach the patient and their family regarding the medications.

Evaluation

It is important to always evaluate the patient's response to the medication. With analgesic medications, the nurse should assess for decrease in pain 30 minutes after IV administration and 60 minutes after oral medication. If the patient's pain level is not acceptable, the nurse should investigate alternate treatment modalities. These modalities may include, but not limited to, aromatherapy, repositioning the patient, hot or cold treatments, and listening to music. As the nurse is the patient advocate, the healthcare provider may have to be informed if the patient's pain is not being controlled by analgesics. One of the adverse effects of opioid analgesics is respiratory depression. The nurse should evaluate the respiratory rate and pulse oximetry after administration of the medication. Other common side effects of opioid analgesic medications are constipation or nausea. The nurse may need to consider administering other medications that treat the side effects of analgesic medication.

10.5 Analgesic and Musculoskeletal Medications

Open Resources for Nursing (Open RN)

As illustrated in the WHO ladder in Figure 10.8, analgesics used to treat pain are categorized as nonopioid, opioid, and adjuvant medications. Nonopioid medications include acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs). There are several types of opioids, as listed previously in Figure 10.7. **Adjuvant analgesics** are defined as drugs with a primary indication other than pain that have analgesic properties in some painful conditions. This group includes numerous drugs in diverse classes such as gabapentin (an anticonvulsant), amitriptyline (a tricyclic antidepressant), or muscle relaxants.

Lussier, D., Huskey, A., & Portenoy, R. (2004). Adjuvant analgesics in cancer pain management. *Oncologist*, 9(5); 571-91. <https://www.ncbi.nlm.nih.gov/pubmed/15477643>.

Each of these classes will be discussed in more detail along with antineoplastic medications and a brief overview of anesthetic medication.

Analgesic and Musculoskeletal Medication Classifications

Let's take a closer look at different classes of analgesics and musculoskeletal medications with specific administration considerations, therapeutic effects, adverse/side effects, and teaching needed for each class of medications. Analgesic and musculoskeletal medications are available in many different forms, such as oral tablets, oral liquids, injections, inhalation, and transdermal. Some products contain more than one medicine (for example, oxycodone and acetaminophen) to enhance pain relief.

10.6 Non-Opioid Analgesics

Open Resources for Nursing (Open RN)

Non-opioid analgesics include acetaminophen and nonsteroidal antiinflammatory drugs (NSAIDs).

Acetaminophen

Mechanism of Action

Acetaminophen inhibits the synthesis of prostaglandins that may serve as mediators of pain and fever primarily in the CNS.

Frandsen, G. & Pennington S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). (pg.305, 310, 952-953, 959-960) Wolters Kluwer.

Indications for Use

Acetaminophen is used to treat mild pain and fever; however, it does not have anti-inflammatory properties.

Nursing Considerations Across the Lifespan

Acetaminophen is safe for all ages and can be administered using various routes.

Geriatric populations should not exceed 3000 mg in 24 hours, and chronic alcoholics should not exceed 2000 mg in 24 hours due to the risk for hepatotoxicity.

Adverse/Side Effects

Adverse effects include skin reddening, blisters, rash, and hepatotoxicity.

Severe liver damage may occur if a patient:

- takes more than 4,000 mg of acetaminophen in 24 hours (3200 mg for geriatric adults, 2000 mg for chronic alcoholics)
- takes with other drugs containing acetaminophen
- consumes 3 or more alcoholic drinks every day while using this product.

Vallerand, A., & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

Some medications are combined with acetaminophen and are prescribed “as needed,” so the nurse must calculate the cumulative dose of acetaminophen over the previous 24-hour period. For example, Percocet 5/325 contains a combination of oxycodone 5 mg and acetaminophen 325 mg and could be ordered 1-2 tablets every 4-6 hours as needed for pain. If 2 tablets are truly administered every 4 hours over a 24-hour period, this would add up to 3900 mg of acetaminophen, which would exceed the recommended guidelines for a geriatric patient and could cause liver damage.

If overdose occurs, the antidote is acetylcysteine.

Patient Teaching & Education

Medications should be taken as directed and the dosing schedule should be adhered to appropriately. Patients should not take the medication for greater than 10 days. Additionally, patients should avoid taking alcohol while using these medications. If a rash occurs, this should be reported to the healthcare provider and the medication should be promptly stopped. Use of medications may interfere with blood glucose monitoring. If a fever lasts longer than three days or exceeds 39.5 C, this should be reported to the healthcare provider.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Now let's take a closer look at the medication grid on acetaminophen in Table 10.6a.

Vallerand, A., & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

Drugs.com [Internet]. *Aspirin*; © 2000-2019 [updated 1 December 28; cited 20 November 2019]. <https://www.drugs.com/aspirin.html>

, footnote]Centers for Disease Control and Prevention. (2019, August 28). *Opioid overdose, CDC guideline for prescribing opioids for chronic pain*. <https://www.cdc.gov/drugoverdose/prescribing/guideline.html>[footnote]

Medication grids are intended to assist students to learn key points about each medication. Because information about medication is constantly changing, nurses should always consult evidence-based resources to review current recommendations before administering specific medication. Basic information related to each class of medication is outlined below. Detailed information on a specific medication can be found for free at Daily Med at <https://dailymed.nlm.nih.gov/dailymed/index.cfm>. On the home page, enter the drug name in the search bar to read more about the medication. Prototype/generic medications listed in the grids below are also hyperlinked directly to a Daily Med page.

Table 10.6a Acetaminophen Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Nonopioid analgesic Antipyretic	acetaminophen	Can be given orally, rectally, and IV Assess pain prior to and after administration Administer with a full glass of water Maximum dose over 24-hour period: -4000 mg for adults, -3200 mg for geriatric patients -2000 mg for patients with chronic alcoholism	Relief of mild pain and fever	Skin reddening Blisters Rash Hepatic failure (liver damage)

Critical Thinking Activity 10.6a

Image of lightbulb in a circle

Your patient is admitted to the hospital with acute liver failure due to acetaminophen toxicity. Your patient reveals that they have had a cold for several days and have been taking over-the-counter cold medications and acetaminophen for a headache. They also mention that every night after work they drink a “few” beers.

What patient education about acetaminophen should be provided?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

Nonsteroidal Antiinflammatories (NSAIDs)

Nonsteroidal antiinflammatories have an analgesic effect, as well as antipyretic and antiinflammatory actions. Some, such as aspirin, also have an antiplatelet effect. Aspirin and other NSAIDs relieve pain by inhibiting the biosynthesis of prostaglandin by different forms of the COX enzyme. COX2 inhibitors are selective and only inhibit the COX-2 enzyme. As a result of the inhibition of COX1 by an NSAID, there is decreased protection of the stomach lining and gastric irritation and bleeding may occur. This section will discuss the following NSAIDs: aspirin, ibuprofen, ketorolac, and celecoxib.

McCuiston, L., E., Vuljoin-DiMaggio, K., Winton, M., B., & Yeager, J. (2018) *Pharmacology: A patient centered nursing process approach*. (pp. 268-270, 324, 332) Elsevier.

Aspirin

Mechanism of Action

Aspirin produces analgesia and reduces inflammation and fever by inhibiting the production of prostaglandins. It also decreases platelet aggregation.

Indications for Use

Aspirin is used for the treatment of mild pain and fever. Once daily dosages are also used to reduce the risk of heart attack and stroke.

Nursing Considerations Across the Lifespan

Aspirin is safe for adults and children older than 12 years of age.

Adverse/Side Effects

Adverse effects include GI upset, GI bleed, and tinnitus (ringing of the ears).

Allergy alert: Aspirin may cause a severe allergic reaction, which may include:

- hives
- facial swelling
- shock
- asthma (wheezing)

Stomach bleeding warning: This product contains an NSAID, which may cause severe stomach bleeding. The chance for bleeding is higher if a patient:

- takes a higher dose or takes it for a longer time than directed
- takes other drugs containing prescription or nonprescription NSAIDs (aspirin, ibuprofen, naproxen, or others)
- has had stomach ulcers or bleeding problems
- takes a blood thinning (anticoagulant) or steroid drug
- is age 60 or older
- has 3 or more alcoholic drinks every day while using this product

Aspirin is contraindicated if the patient has a bleeding disorder such as hemophilia or a recent history of bleeding in the stomach or intestine.

Patient Teaching & Education

Patients should avoid concurrent use of alcohol while taking medication to avoid gastric irritation. Additionally, they should report tinnitus, unusual bleeding, or fever lasting greater than 3 days to the healthcare provider.

Black Box Warning

Children or teenagers should not take aspirin to treat chickenpox or flu-like symptoms because of the risk of Reye's Syndrome. Reye's Syndrome primarily occurs in children in conjunction with a viral illness; it can cause symptoms such as persistent vomiting, confusion or loss of consciousness and requires immediate medical attention.

Now let's take a closer look at the medication grid on aspirin in Table 10.6b.

Frandsen, G. & Pennington S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). (pg.305, 310, 952-953, 959-960) Wolters Kluwer.

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Vallerand, A. & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurse* (16th ed.). F.A. Davis Company.

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Drugs.com [Internet]. *Aspirin*; © 2000-2019 [; updated 1 December 28; cited 20 November 2019]. <https://www.drugs.com/aspirin.html>

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Centers for Disease Control and Prevention. (2019, August 28). *Opioid overdose, CDC guideline for prescribing opioids for chronic pain*. <https://www.cdc.gov/drugoverdose/prescribing/guideline.html>.

Table 10.6b Aspirin Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Nonopioid analgesic (NSAID) Antipyretic	aspirin	Give orally Assess pain prior to and after administration Children under 12 years: do not use unless directed by a provider Take with a full glass of water and sit upright for 15-30 minutes after administration Take with food if the patient reports that aspirin upsets their stomach Do not crush, chew, break, or open an enteric-coated or delayed-release pill; it should be swallowed whole The chewable tablet form must be chewed before swallowing Should be stopped 7 days prior to surgery due to the risk of postoperative bleeding	Treatment of mild pain and fever Reduces the risk of heart attack and stroke	GI upset GI bleeding Tinnitus

Critical Thinking Activity 10.6b

Image of lightbulb in a circle

A patient asks why aspirin is given to prevent a heart attack or stroke.

What is the nurse's response?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Ibuprofen

Mechanism of Action

Ibuprofen inhibits prostaglandin synthesis.

Indications for Use

Ibuprofen is used to treat mild to moderate pain and fever, inflammatory disorders including rheumatoid arthritis and osteoarthritis, and pain associated with dysmenorrhea.

Nursing Considerations Across the Lifespan

Ibuprofen is safe for infants 6 months or older. It is especially important not to use ibuprofen during the last 3 months of pregnancy unless directed to do so by a doctor because it may cause complications during delivery or in the unborn child.

Adverse/Side Effects

Adverse effects include headache, GI bleed, constipation, dyspepsia, nausea, vomiting, Steven-Johnson syndrome, and renal failure.

Allergy alert: Ibuprofen may cause a severe allergic reaction, especially in people allergic to aspirin. Symptoms may include:

- hives
- facial swelling
- asthma (wheezing)
- shock
- skin reddening

- rash
- blisters

Patient Teaching & Education

Patients should consume the medication with a full glass of water and remain upright for 30 minutes following medication administration. They should avoid the use of alcohol while taking this medication. Patients should be advised to not take the medication for longer than 10 days. If the patient notices rash, visual changes, tinnitus, weight gain, or influenza-like symptoms, these should be reported to the healthcare provider immediately.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Stomach bleeding warning:

This product contains a nonsteroidal anti-inflammatory drug (NSAID), which may cause severe stomach bleeding. The chance for bleeding is higher if the patient:

- is age 60 or older
- has had stomach ulcers or bleeding problems
- takes a blood thinning (anticoagulant) or steroid drug
- takes other drugs containing prescription or nonprescription NSAIDs (aspirin, ibuprofen, naproxen, or others)
- has 3 or more alcoholic drinks every day while using this product
- takes more or for a longer time than directed

Heart attack and stroke warning:

All NSAIDs, except aspirin, increase the risk of heart attack, heart failure, and stroke. These can be fatal. The risk is higher if the patient takes more than is directed or takes it for longer than directed.

Black Box Warning

Ibuprofen is contraindicated for the treatment of perioperative pain after coronary artery bypass graft.

Now let's take a closer look at the medication grid on ibuprofen in Table 10.6c.

Frandsen, G. & Pennington S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). (pg.305, 310, 952-953, 959-960) Wolters Kluwer.

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Vallerand, A. & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurse* (16th ed.). F.A. Davis Company.

Table 10.6c Ibuprofen Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Nonopioid analgesic	ibuprofen	Given parenterally and orally	To relieve mild pain and to reduce fever	Headache

NSAID Antipyretic		Assess pain prior to and after administration May take with food or milk if stomach upset occurs Stay well hydrated to prevent renal failure Assess patient for signs of GI bleed Assess for skin rash Monitor BUN, serum creatinine, CBC, and liver function test Do not administer to patients who are allergic to aspirin or other NSAIDs		GI bleed Constipation Dyspepsia Nausea Vomiting Steven-Johnson syndrome Renal failure
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Critical Thinking Activity 10.6c

Image of lightbulb in a circle

A patient who is a chronic alcoholic asks if it is okay to take ibuprofen for knee pain.

What is the nurse's best response?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Ketorolac

Ketorolac is an NSAID that is commonly used to treat "breakthrough" pain that occurs during the

treatment of severe acute pain being treated with opioids.

Mechanism of Action

Ketorolac inhibits prostaglandin synthesis.

Indications for Use

Ketorolac is indicated for the short-term (up to 5 days in adults) management of moderate to severe acute pain that requires analgesia at the opioid level.

Nursing Considerations Across the Lifespan

Ketorolac is safe for adults. This dose should be reduced for patients ages 65 and over.

Adverse/Side Effects

Adverse effects include drowsiness, headache, GI bleed, abnormal taste, dyspepsia, nausea, Steven-Johnson syndrome, edema, and renal failure.

Patient Teaching & Education

The use of ketorolac may cause dizziness or drowsiness. Patients should also avoid alcohol or other aspirin-containing products unless directed by their healthcare provider. If the patient notices rash, visual changes, tinnitus, weight gain, or influenza-like symptoms, these should be reported to the healthcare provider immediately.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Gastrointestinal Risk

Ketorolac tromethamine (IV form) can cause peptic ulcers, gastrointestinal bleeding, and/or perforation of the stomach or intestines, which can be fatal. These events can occur at any time during use and without warning symptoms. Therefore, ketorolac tromethamine is contraindicated in patients with active peptic ulcer disease, in patients with recent gastrointestinal bleeding or perforation, and in patients with a history of peptic ulcer disease or gastrointestinal bleeding. Elderly patients are at greater risk for serious gastrointestinal events.

Cardiovascular Thrombotic Events

Nonsteroidal anti-inflammatory drugs (NSAIDs) cause an increased risk of serious cardiovascular thrombotic events, including myocardial infarction and stroke, which can be fatal. This risk may occur early in treatment and may increase with duration of use.

Ketorolac tromethamine is contraindicated for patients who have recently received coronary artery bypass graft (CABG) surgery.

Renal Risk

Ketorolac tromethamine is contraindicated in patients with advanced renal impairment and in patients at risk for renal failure due to volume depletion.

Risk of Bleeding

Ketorolac tromethamine inhibits platelet function and is, therefore, contraindicated in patients with suspected or confirmed cerebrovascular bleeding, hemorrhagic diathesis, incomplete hemostasis, and a high risk of bleeding. Ketorolac tromethamine is contraindicated as a prophylactic analgesic before any major surgery.

Hypersensitivity Reactions

Hypersensitivity reactions ranging from bronchospasm to anaphylactic shock have occurred and appropriate counteractive measures must be available when administering the first dose of ketorolac. Ketorolac tromethamine is contraindicated in patients with previously demonstrated hypersensitivity to ketorolac tromethamine or who have had allergic manifestations to aspirin or other nonsteroidal anti-inflammatory drugs (NSAIDs).

Now let's take a closer look at the medication grid on ketorolac in Table 10.6d.

Vallerand, A. & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurse* (16th ed.). F.A. Davis Company.

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Table 10.6d Ketorolac Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Nonopioid analgesic NSAID	ketorolac	Given orally, parenterally and as an ophthalmic solution Assess pain prior to and after administration Therapy should always be given initially by the IM or IV route; then use the oral route as a continuation of parenteral therapy Stay well hydrated to prevent renal failure Assess patient for signs of GI bleed Assess for skin rash	To relieve moderate pain short term (not to exceed 5 days)	Drowsiness Headache GI bleed Abnormal taste Dyspepsia Nausea Steven-Johnson syndrome Edema Renal failure

		Monitor BUN, serum creatinine, CBC, and liver function tests Do not administer before any major surgery Do not administer to patients who are allergic to aspirin or other NSAIDs		
--	--	--	--	--

Critical Thinking Activity 10.6d

Image of lightbulb in a circle

Ketorolac IV was administered to a patient for severe pain (rated as “8”) due to a back injury.

When should the effectiveness of the medication be evaluated?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

Celecoxib

Celecoxib is a COX-2 inhibitor.

Mechanism of Action

Celecoxib specifically inhibits the enzyme COX-2 that is required for the synthesis of prostaglandins.

Indications for Use

Celecoxib is used to treat the pain associated with osteoarthritis, rheumatoid arthritis (including juvenile), and ankylosing spondylitis. It also relieves the pain associated with dysmenorrhea.

Nursing Considerations Across the Lifespan

Celecoxib is safe for children 2 years or older. Dosage adjustment is required for patients with hepatic impairment (see Black Box Warning).

Adverse/Side Effects

Adverse effects include hypertension, peripheral edema, increased liver enzymes, abdominal pain, dyspepsia, gastroesophageal reflux disease, vomiting, and diarrhea.

There are Black Box Warnings for increased risk of cardiovascular (CV) events and gastrointestinal bleeding, ulceration, and perforation. See more information about each condition below.

Patient Teaching & Education

Patients should take medication as directed and use the lowest effective dose for the shortest period of time. If signs of GI toxicity occur, these should be reported immediately to the healthcare provider. uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Cardiovascular Thrombotic Events

Nonsteroidal anti-inflammatory drugs (NSAIDs) cause an increased risk of serious cardiovascular thrombotic events, including myocardial infarction and stroke, which can be fatal. This risk may occur early in the treatment and may increase with duration of use. Celecoxib capsules are contraindicated in patients who have recently received coronary artery bypass graft (CABG) surgery.

Gastrointestinal Bleeding, Ulceration, and Perforation

NSAIDs cause an increased risk of serious gastrointestinal (GI) adverse events including bleeding, ulceration, and perforation of the stomach or intestines, which can be fatal. These events can occur at any time during use and without warning symptoms. Elderly patients and patients with a prior history of peptic ulcer disease and/or GI bleeding are at greater risk for serious (GI) events.

Now let's take a closer look at the medication grid on celecoxib in Table 10.6e.

Vallerand, A. & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurse* (16th ed.). F.A. Davis Company.

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Table 10.6e Celecoxib Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
NSAIDs COX-2 inhibitor	celecoxib	May be given with or without food May sprinkle capsules on applesauce and ingest	To decrease pain and inflammation caused by arthritis or spondylitis	Hypertension Peripheral edema Increased liver

		immediately with water Monitor patients for signs and symptoms of Steven-Johnson syndrome Monitor for signs and symptoms of GI bleed, hypertension, and heart failure Monitor liver enzymes	enzymes Abdominal pain, dyspepsia, gastroesophageal reflux disease, vomiting, and diarrhea Cardiovascular thrombotic events GI bleeding, ulceration and perforation Hepatotoxicity Hypertension Heart failure and edema Renal toxicity and hyperkalemia Anaphylactic reactions Serious skin reactions Hematologic toxicity
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Critical Thinking Activity 10.6e

Image of lightbulb in a circle

A patient has been prescribed celecoxib for their arthritic pain.

What patient teaching does the nurse plan to provide?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

10.7 Opioid Analgesics and Antagonists

Open Resources for Nursing (Open RN)

Opioid analgesics are prescribed for moderate and severe pain. See Figure 10.8 in the “Nursing Process” section for a list of common opioid medications used to treat moderate to severe pain. As discussed in that section, morphine is at the top of the WHO ladder and is used to treat severe pain. It is also commonly used to treat cancer pain and for pain at end of life because there is no “ceiling effect,” meaning the higher the dose, the higher the level of analgesia. Morphine is also commonly used in **patient controlled analgesia (PCA)**; other medications administered via PCA include hydromorphone or fentanyl. To receive the opioid using a PCA device, the patient pushes a button, which releases a specific dose but also has a lockout mechanism to prevent an overdose.

McCuiston, L., Vuljoin-DiMaggio, K., Winton, M, & Yeager, J. (2018). *Pharmacology: A patient-centered nursing process approach*. pp. 268-270, 324, 332. Elsevier.

Morphine

Morphine is an example of an opioid used to treat moderate to severe pain.

Mechanism of Action

Morphine binds to opioid receptors in the CNS and alters the perception of and response to painful stimuli while producing generalized CNS depression.

Indications for Use

Morphine is indicated for the relief of moderate to severe acute and chronic pain and for pulmonary edema.

Nursing Considerations Across the Lifespan

Morphine is safe for all ages. Use cautiously with patients with liver and renal impairment.

Adverse/Side Effects

Adverse effects include respiratory depression, hypotension, light-headedness, dizziness, sedation, constipation, nausea, vomiting, and sweating.

Patient Teaching & Education

Patients should be advised regarding the risks associated with opioid analgesic use. Please see the outlined “Special Considerations” for usage below.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Black Box Warning

The risk of serious adverse reactions, including slowed or difficulty breathing and death, have been reported with the combined effects of morphine with other CNS depressants. Naloxone is used to reverse opioid overdose. There is also a risk of drug abuse and dependence with morphine.

Special Considerations

Respiratory Depression

Respiratory depression is the primary risk of morphine sulfate. Respiratory depression occurs more frequently in elderly or debilitated patients and in those suffering from conditions accompanied by hypoxia, hypercapnia, or upper airway obstruction, for whom even moderate therapeutic doses may significantly decrease pulmonary ventilation.

Use morphine with extreme caution in patients with chronic obstructive pulmonary disease or cor pulmonale and in patients having a substantially decreased respiratory reserve, hypoxia, hypercapnia, or pre-existing respiratory depression. In such patients, even usual therapeutic doses of morphine sulfate may increase airway resistance and decrease respiratory drive to the point of apnea. Consider alternative non-opioid analgesics, and use morphine sulfate only under careful medical supervision at the lowest effective dose in such patients.

Misuse, Abuse, and Diversion of Opioids

Morphine sulfate is an opioid agonist and a Schedule II controlled substance. Such drugs are sought by drug abusers and people with addiction disorders. Diversion of Schedule II products is an act subject to criminal penalty.

Morphine can be abused in a manner similar to other opioid agonists, legal or illicit. This should be considered when prescribing or dispensing morphine sulfate in situations where there is increased risk of misuse, abuse, or diversion. Morphine may be abused by crushing, chewing, snorting, or injecting the product. These practices pose a significant risk to the abuser that could result in overdose and death.

Interactions with Alcohol and Drugs of Abuse

Morphine has addictive effects when used in conjunction with alcohol, other opioids, or illicit drugs that cause central nervous system depression because respiratory depression, hypotension, profound sedation, coma, or death may result.

Use In Head Injury and Increased Intracranial Pressure

In the presence of head injury, intracranial lesions, or a preexisting increase in intracranial pressure, the possible respiratory depressant effects of morphine and its potential to elevate cerebrospinal fluid pressure may be markedly exaggerated. Furthermore, morphine can produce effects on pupillary response and consciousness, which may obscure neurologic signs of increased intracranial pressure in patients with head injuries.

Hypotensive Effect

Morphine may cause severe hypotension in individuals unable to maintain blood pressure who have already been compromised by a depleted blood volume or drug administration of phenothiazines or general anesthetics.

Administer morphine sulfate with caution to patients in circulatory shock, as vasodilation produced by the drug may further reduce cardiac output and blood pressure.

Gastrointestinal Effects

Do not administer morphine to patients with gastrointestinal obstruction, especially paralytic ileus because morphine diminishes propulsive peristaltic waves in the gastrointestinal tract and may prolong the obstruction.

The administration of morphine sulfate may obscure the diagnosis or clinical course in patients with an acute abdominal condition.

Use in Pancreatic/Biliary Tract Disease

Use morphine with caution in patients with biliary tract disease, including acute pancreatitis, as morphine sulfate may cause spasming and diminished biliary and pancreatic secretions.

Special Risk Groups

Use morphine with caution and in reduced dosages in patients with severe renal or hepatic impairment, Addison's disease, hypothyroidism, prostatic hypertrophy, or urethral stricture, and in elderly or debilitated patients. Exercise caution in the administration of morphine sulfate to patients with CNS depression, toxic psychosis, acute alcoholism, and delirium tremens.

All opioids may aggravate convulsions in patients with convulsive disorders, and all opioids may induce or aggravate seizures.

Driving and Operating Machinery

Caution patients that morphine sulfate could impair the mental and/or physical abilities needed to perform potentially hazardous activities such as driving a car or operating machinery.

Caution patients about the potential combined effects of morphine sulfate with other CNS depressants, including other opioids, phenothiazines, sedative/hypnotics, and alcohol.

Now let's take a closer look at the medication grid on morphine in Table 10.7a.

Frandsen, G., Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice (11th ed.)*. (pg. 305, 310, 952-953, 959-960). Wolters Kluwer.

Vallerand, A. & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses*, (16th ed.). F.A. Davis Company.

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Table 10.7a Morphine Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Opioid analgesic	morphine	Given parenterally and orally Assess pain prior to and after administration Monitor respiratory status Monitor blood pressure Assess pediatric and geriatric patients frequently Assess bowel function Use cautiously with antidepressants and other CNS depressants Naloxone is used to reverse opioid overdose	Relieves moderate to severe pain	Respiratory depression Confusion Hypotension Light- headedness Dizziness Sedation Constipation Nausea and vomiting Sweating

Critical Thinking Activity 10.7a

Image of lightbulb in a circle

Oral morphine was administered to a patient for rib pain (rated as “6”) from metastatic lung cancer.

When should the effectiveness of the medication be evaluated?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

Concerns Related to Opioid Use

CDC Guidelines for Prescribing Opioids for Chronic Pain

Improving the prescription of opioids through clinical practice guidelines can ensure patients have access to safer, effective pain treatment while also reducing the number of people who misuse or overdose from these drugs.

The CDC developed and published the *CDC Guideline for Prescribing Opioids for Chronic Pain* to provide recommendations for the prescribing of opioid pain medication for patients 18 and older in primary care settings. Recommendations focus on the use of opioids in treating chronic pain (pain lasting longer than 3 months or past the time of normal tissue healing) outside of active cancer treatment, palliative care, and end-of-life care.

Centers for Disease Control and Prevention. (2019, August 28). Opioid overdose, CDC guideline for prescribing opioids for chronic pain. <https://www.cdc.gov/drugoverdose/prescribing/guideline.html>

The Need

Improving the way opioids are prescribed through clinical practice guidelines can ensure patients have access to safer, more effective chronic pain treatment while reducing the risk of opioid use disorder, overdose, and death.

- More than 11.5 million Americans aged 12 or older reported misusing prescription opioids in 2016.
- An estimated 11% of adults experience daily pain.
- Millions of Americans are treated with prescription opioids for chronic pain.
- Primary care providers are concerned about patient addiction and report insufficient training in prescribing opioids.

Guideline Overview

The *CDC Guideline* addresses patient-centered clinical practices including conducting thorough assessments, considering all possible treatments, closely monitoring risks, and safely discontinuing opioids. The three main focus areas in the guideline include:

1. Determining when to initiate or continue opioids for chronic pain

- Selection of non-pharmacologic therapy, nonopioid pharmacologic therapy, opioid therapy
- Establishment of treatment goals
- Discussion of risks and benefits of therapy with patients

2. Opioid selection, dosage, duration, follow-up, and discontinuation

- Selection of immediate-release or extended-release and long-acting opioids
- Dosage considerations
- Duration of treatment

3. Considerations for follow-up and discontinuation of opioid therapy

- Assessing risk and addressing harms of opioid use
- Evaluation of risk factors for opioid-related harms and ways to mitigate patient risk
- Review of prescription drug monitoring program (PDMP) data
- Use of urine drug testing
- Considerations for co-prescribing benzodiazepines
- Arrangement of treatment for opioid use disorder

Centers for Disease Control and Prevention. (2019, August 28). Opioid overdose, CDC guideline for prescribing opioids for chronic pain. <https://www.cdc.gov/drugoverdose/prescribing/guideline.html>

Understanding the Epidemic

Drug overdose deaths continue to increase in the United States. From 1999 to 2017, more than 700,000 people have died from a drug overdose. Around 68% of the more than 70,200 drug overdose deaths in 2017 involved an opioid. In 2017, the number of overdose deaths involving opioids (including prescription opioids and illegal opioids like heroin and illicitly manufactured fentanyl) was 6 times higher than in 1999. On average, 130 Americans die every day from an opioid overdose.

Centers for Disease Control and Prevention. (2018, December 19). Opioid Overdose, Understanding the Epidemic. <https://www.cdc.gov/drugoverdose/epidemic/index.html>.

From 1999-2017, almost 400,000 people died from an overdose involving any opioid, including prescription and illicit opioids. This rise in opioid overdose deaths can be outlined in three distinct waves. See Figure 10.9 for a graphic representation of the waves of opioid deaths.

"[3 Waves of the Rise of Opioid Overdose Deaths](#)" by National Vital Statics System, CDC is licensed under [CC0](#)

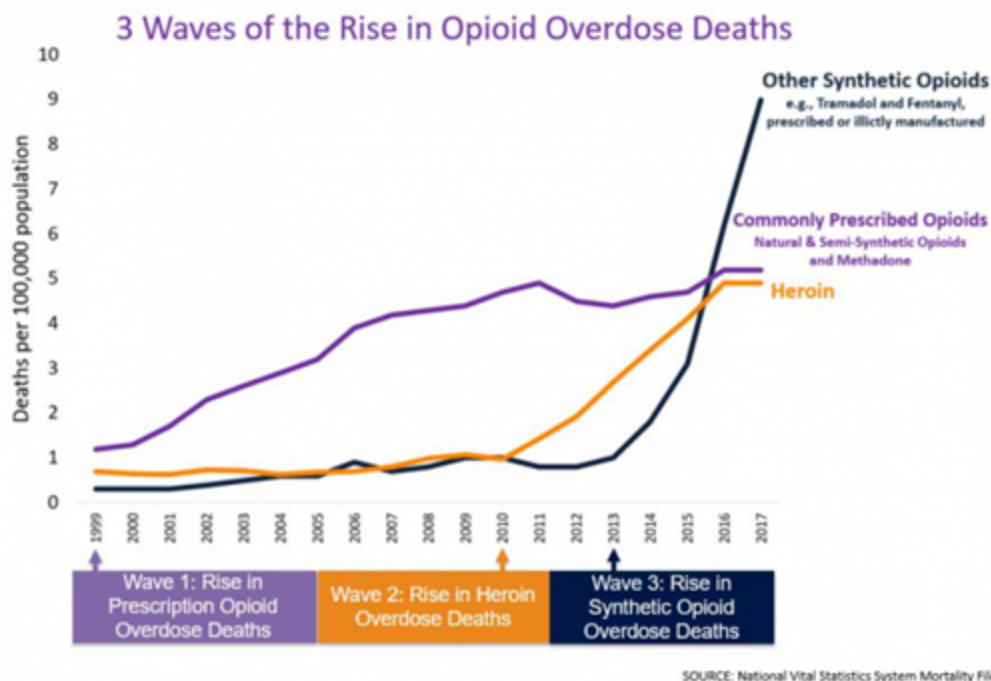


Figure 10.9 Three Waves of Opioid Overdose Deaths

The first wave began with increased prescribing of opioids in the 1990s, with overdose deaths involving prescription opioids (natural and semi-synthetic opioids and methadone). The second wave began in 2010 with rapid increases in overdose deaths involving heroin. The third wave began in 2013, with significant increases in overdose deaths involving synthetic opioids – particularly those involving illicitly-manufactured fentanyl.

Centers for Disease Control and Prevention. (2018, December 19). Opioid Overdose, Understanding the Epidemic.
<https://www.cdc.gov/drugoverdose/epidemic/index.html>.

Combating the Opioid Overdose Epidemic

The CDC is committed to fighting the opioid overdose epidemic and supporting states and communities as they continue work to identify outbreaks, collect data, respond to overdoses, and provide care to those in their communities. CDC's Prevention for States and Data-Driven Prevention Initiative programs aims center around the enhancement of PDMPs within clinical and public health settings, insurer and community interventions, evaluation of state-level policies, and other innovative strategies that states can employ.

CDC's Enhanced State Opioid Overdose Surveillance program aims to support and build the capacity of states to monitor the epidemic by improving the timeliness and quality of surveillance data focusing on both fatal and nonfatal opioid overdose.

Centers for Disease Control and Prevention. (2018, December 19). Opioid Overdose, Understanding the Epidemic.
<https://www.cdc.gov/drugoverdose/epidemic/index.html>.

IV Drug Diversion and Impaired Health Care Workers

In every organization, drug diversion is a potential threat to patient safety. Risks to patients include inadequate pain relief and exposure to infectious diseases from contaminated needles and drugs, compounded by potentially unsafe care due to the health care worker's impaired performance.

Furthermore, diversion may cause undue suffering to patients who don't receive analgesic relief, can be costly to an organization by damaging its reputation, and may lead to major civil and criminal monetary penalties

The Joint Commission, Division of Healthcare Improvement. (2019). Drug diversion and impaired health care workers. *Quick Safety* (48).

More information about surveillance programs, drug diversion, and impaired health workers is included in the "Legal/Ethical" chapter.

[Download the PDF](#) to read the full article by the Joint Commission.

Naloxone (Narcan)

Mechanism of Action

Naloxone reverses analgesia and the CNS and respiratory depression caused by opioid agonists. It competes with opioid receptor sites in the brain and, thereby, prevents binding with receptors or displaces opioids already occupying receptor sites.

Indications for Use

Naloxone is indicated for the complete or partial reversal of opioid depression, including respiratory depression induced by natural and synthetic opioids.

Nursing Considerations Across the Lifespan

Naloxone is safe for all ages.

Adverse/Side Effects

Adverse effects include tremors, drowsiness, sweating, decreased respirations, hypertension, nausea, and vomiting.

Patient Teaching & Education

Patients should be advised regarding the risks associated with opioid analgesic use and the need for opioid antagonists. Please see the outlined "Special Considerations" for usage below.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Special Considerations

Postoperative

The following adverse events have been associated with the use of naloxone hydrochloride injection in postoperative patients: hypotension, hypertension, ventricular tachycardia and fibrillation, dyspnea, pulmonary edema, and cardiac arrest. Death, coma, and encephalopathy have been reported as results of these events. Excessive doses of naloxone in postoperative patients may result in significant reversal of analgesia and may cause agitation.

Opioid Depression

Abrupt reversal of opioid depression may result in nausea, vomiting, sweating, tachycardia, increased blood pressure, tremulousness, seizures, ventricular tachycardia and fibrillation, pulmonary edema, and cardiac arrest, which may result in death.

Opioid Dependence

Abrupt reversal of opioid effects in persons who are physically dependent on opioids may precipitate an acute withdrawal syndrome, which may include, but not limited to, the following signs and symptoms: body aches, fever, sweating, runny nose, sneezing, piloerection, yawning, weakness, shivering or trembling, nervousness, restlessness or irritability, diarrhea, nausea or vomiting, abdominal cramps, increased blood pressure, and tachycardia. In the neonate, opioid withdrawal may also include convulsions, excessive crying, and hyperactive reflexes.

Now let's take a closer look at the medication grid on naloxone in Table 10.7b.

Frandsen, G., Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice (11th ed.)*. (pg. 305, 310, 952-953, 959-960). Wolters Kluwer.

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Table 10.7b Naloxone Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Opioid antagonist	naloxone	Given parenterally and inhaled Assess for reversal of opioid effect Assess for hypertension Assess for return of pain Naloxone has a shorter duration of action than opioids, and repeated doses are usually necessary	Blocks the effects of opioid CNS and respiratory depression	Agitation Tremors Drowsiness Sweating Decreased respirations Hypertension Nausea and vomiting

Critical Thinking Activity 10.7b

Image of lightbulb in a circle

A post-operative patient just received naloxone for respiratory depression.

When should the patient's respiratory status be reassessed?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

10.8 Adjuvant Analgesics

Open Resources for Nursing (Open RN)

Medications used as adjuvant analgesics have been developed for other purposes but were later found to be effective to treat pain. Examples of adjuvant medications include gabapentin (an anticonvulsant) and amitriptyline (a tricyclic antidepressant). Additional information about these specific medications can be found in the “Central Nervous System” chapter. Muscle relaxants are also considered an adjuvant analgesic and are used for various musculoskeletal disorders such as multiple sclerosis. Three different types of muscle relaxants will be discussed below: baclofen, cyclobenzaprine, and tizanidine.

Baclofen

Mechanism of Action

Baclofen inhibits reflexes at the spinal level.

Indications for Use

Baclofen is used to treat muscle symptoms, such as spasm, pain, and stiffness, caused by multiple sclerosis, spinal cord injuries, or other spinal cord disorders.

Nursing Considerations Across the Lifespan

Baclofen is safe for patients 12 years and older.

Adverse/Side Effects

Adverse effects include drowsiness, dizziness or lightheadedness, confusion, nausea, constipation, and muscle weakness.

Abrupt Drug Withdrawal: Hallucinations and seizures have occurred on abrupt withdrawal of baclofen. Therefore, except for serious adverse reactions, the dose should be reduced slowly when the drug is discontinued.

Impaired Renal Function: Because baclofen is primarily excreted unchanged through the kidneys, it should be given with caution, and it may be necessary to reduce the dosage.

Signs and symptoms of overdose include vomiting, muscular hypotonia, drowsiness, accommodation disorders of the eye, coma, respiratory depression, and seizures.

Patient Teaching & Education

The medication should be taken as directed and abrupt withdrawal of the medication should be avoided. It may cause dizziness or drowsiness. Patients should be advised to change positions slowly because of the potential orthostatic changes that may occur. Additionally, patients should avoid concurrent use with alcohol or other CNS depressants.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Now let's take a closer look at the medication grid on baclofen in Table 10.8a.

Vallerand, A., Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

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Table 10.8a Baclofen Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Skeletal muscle relaxant and antispasticity agent	baclofen	Given parentally and orally Administer orally with milk or food to minimize gastric upset Assess for muscle spasticity before and during therapy Observe patient for drowsiness For intrathecal administration monitor patient closely during test dose and titration	To relieve muscle spasms and spasticity	Drowsiness Confusion Dizziness or light- headedness Nausea Constipation Muscle weakness

		and have resuscitative equipment available		
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Critical Thinking Activity 10.8a

Image of lightbulb in a circle

A patient just started taking baclofen for muscle spasticity due to multiple sclerosis.

What teaching should the nurse provide?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

Cyclobenzaprine

Mechanism of Action

Cyclobenzaprine reduces tonic somatic muscle activity at the level of the brainstem. It is structurally similar to tricyclic antidepressants.

Indications for Use

Cyclobenzaprine is used to treat acute muscle spasms.

Nursing Considerations Across the Lifespan

Cyclobenzaprine is safe for patients 15 years and older. Use cautiously with geriatric patients, patients with hepatic impairment, and those who take antidepressants and other CNS depressants.

In the elderly, the frequency and severity of adverse events associated with the use of cyclobenzaprine, with or without concomitant medications, are increased. In elderly patients, cyclobenzaprine should be initiated with a 5 mg dose and titrated slowly upward.

Adverse/Side Effects

Adverse effects include dizziness, drowsiness, dry mouth, urinary retention, serotonin syndrome with antidepressant use, or increased sedation with other CNS depressants.

Patient Teaching & Education

The medication should be taken as directed. It may cause dizziness or drowsiness. Patients should be advised to change positions slowly because of the potential orthostatic changes that may occur. Additionally, patients should avoid concurrent use with alcohol or other CNS depressants. Patients should be aware that constipation may occur as a side effect of medication therapy and increased fluid intake may assist in preventing complications.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Serotonin Syndrome

The development of a potentially life-threatening serotonin syndrome has been reported with cyclobenzaprine hydrochloride when used in combination with other drugs, such as selective serotonin reuptake inhibitors (SSRIs), serotonin norepinephrine reuptake inhibitors (SNRIs), tricyclic antidepressants (TCAs), tramadol, bupropion, meperidine, verapamil, or MAO inhibitors (MAOIs). The concomitant use of cyclobenzaprine hydrochloride with MAO inhibitors is contraindicated.

Serotonin syndrome symptoms may include mental status changes (e.g., confusion, agitation, hallucinations), autonomic instability (e.g., diaphoresis, tachycardia, labile blood pressure, hyperthermia), neuromuscular abnormalities (e.g., tremor, ataxia, hyperreflexia, clonus, muscle rigidity), and/or gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea). Treatment with cyclobenzaprine hydrochloride and any concomitant serotonergic agents should be discontinued immediately if the above reactions occur, and supportive symptomatic treatment should be initiated. If concomitant treatment with cyclobenzaprine hydrochloride and other serotonergic drugs is clinically warranted, careful observation is advised, particularly during treatment initiation or dose increases.

General

Because of its atropine-like action, cyclobenzaprine hydrochloride should be used with caution in patients with a history of urinary retention, angle-closure glaucoma, increased intraocular pressure, and in those taking anticholinergic medication.

Impaired Hepatic Function

The plasma concentration of cyclobenzaprine is increased in patients with hepatic impairment.

Cyclobenzaprine, especially when used with alcohol or other CNS depressants, may impair mental and/or physical abilities required for performance of hazardous tasks, such as operating machinery or driving a motor vehicle.

Now let's take a closer look at the medication grid on cyclobenzaprine in Table 10.8b.

Vallerand, A., Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

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Table 10.8b Cyclobenzaprine Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Skeletal muscle relaxant	cyclobenzaprine	May be administered with meals to minimize GI upset Assess patient for pain and muscle stiffness Use cautiously with antidepressants and other CNS depressants	Reduction of muscle spasms	Dizziness Drowsiness Dry mouth Urinary retention Serotonin syndrome

Critical Thinking Activity 10.8b

Image of lightbulb in a circle

A patient asks if they can drive their car while taking cyclobenzaprine.

What is the nurse's best response?

Note: Answers to the Critical Thinking activities can be found in the "Answer Key" sections at the end of the book.

Tizanidine

Mechanism of Action

Tizanidine acts as an agonist at central alpha-adrenergic receptor sites. It reduces spasticity by increasing presynaptic inhibition of motor neurons.

Indications for Use

Tizanidine is used to treat increased muscle tone, spasms, and spasticity.

Nursing Considerations Across the Lifespan

Tizanidine is safe for adults. Dosage adjustment may be required for the geriatric population.

Adverse/Side Effects

Adverse effects include somnolence, dry mouth, hypotension, bradycardia, dizziness, fatigue, weakness or asthenia, hallucinations, liver function test abnormality, and hepatotoxicity.

Patient Teaching & Education

The medication should be taken as directed. It may cause dizziness or drowsiness. Patients should be advised to change positions slowly because of the potential orthostatic changes that may occur. Additionally, patients should avoid concurrent use with alcohol or other CNS depressants.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Now let's take a closer look at the medication grid on tizanidine in Table 10.8c.

Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pg. 305, 310, 952-953, 959-960. Wolters Kluwer.

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Vallerand, A., Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

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Table 10.8c Tizanidine Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Antispasticity	tizanidine	Given orally May be given with or without food Assess muscle spasticity before and during therapy Assess blood pressure and pulse Monitor for sedation Assess liver function	Reduction of muscle spasms and spasticity	Somnolence Dry mouth Hypotension Bradycardia Dizziness Fatigue Weakness or asthenia Hallucinations

				Liver function test abnormality and hepatotoxicity
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Critical Thinking Activity 10.8c

Image of lightbulb in a circle

A patient asks, “Why should I not drink alcohol with tizanidine?”

What is the nurse’s best response?

Note: Answers to the Critical Thinking activities can be found in the “Answer Key” sections at the end of the book.

10.9 Antigout

Open Resources for Nursing (Open RN)

Antigout medications are used to treat gout, a musculoskeletal disorder. Some antigout medications, such as colchicine, are classified as anti-inflammatory medication. Allopurinol is commonly used to prevent gout from recurring.

Allopurinol

Mechanism of Action

Allopurinol blocks the production of uric acid by inhibiting the action of xanthine oxidase.

Vallerand, A., & Sanoski, C. A. (2019). *Davis’s Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

Indications for Use

Allopurinol is used for the prevention and treatment of gouty arthritis and nephropathy and for the treatment of secondary hyperuricemia.

Nursing Considerations Across the Lifespan

Allopurinol is safe for all ages. For patients with renal impairment, the dose will be reduced.

Adverse/Side Effects

Adverse effects include hypotension, flushing, hypertension, drowsiness, nausea and vomiting, diarrhea, hepatitis, renal failure, or a drug rash with eosinophilia and systemic symptoms (DRESS) syndrome or drug hypersensitivity syndrome.

Cleveland Clinic. (2017, January 26). *Acute v. chronic pain*. <https://my.clevelandclinic.org/health/articles/12051-acute-vs-chronic-pain>.

Patient Teaching & Education

The medication should be taken as directed. An alkaline diet may be ordered for the patient, and they may be advised to increase fluid intake to prevent kidney stone formation. The medication may cause dizziness or drowsiness. Patients who consume large amounts of alcohol may increase uric acid concentrations and decrease the effectiveness of the medication. If patients develop a rash or blood in the urine, this should be reported promptly to the healthcare provider.

uCentral from Unbound Medicine. <https://www.unboundmedicine.com/ucentral>

Now let's take a closer look at the medication grid on allopurinol in Table 10.9.

Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pg. 305, 310, 952-953, 959-960. Wolters Kluwer.

Vallerand, A., & Sanoski, C. A. (2019). *Davis's Drug Guide for Nurses* (16th ed.). F.A. Davis Company.

Centers for Disease Control and Prevention. (2019, August 28). *Opioid overdose, CDC guideline for prescribing opioids for chronic pain*. <https://www.cdc.gov/drugoverdose/prescribing/guideline.html>.

Table 10.9 Allopurinol Medication Grid

Class/ Subclass	Prototype- generic	Administration Considerations	Therapeutic Effects	Adverse/Side Effects
Antigout agent	allopurinol	May be given with milk or meals to decrease stomach upset Give with plenty of water May be crushed Monitor patient's intake and output	Prevention and treatment of attacks of gouty arthritis and nephropathy Treatment of secondary hyperuricemia	Hypotension Flushing Hypertension Drowsiness Nausea and vomiting

		Monitor hematologic, renal, and liver functions before and during therapy If rash occurs, notify healthcare provider	Diarrhea Hepatitis Rash Renal failure
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10.10 Anesthetics

Open Resources for Nursing (Open RN)

As a nurse, you may care for a patient prior to surgery (preoperative), during surgery (perioperative), or after surgery (postoperative). One of your roles is to monitor your patient's vital signs, paying close attention to respiratory status (respiratory rate, depth, quality, and SpO₂). You will also assess LOC (level of consciousness) and pain level. Below is a description of the types of anesthetics.

Local

Local anesthetic is when a medication (e.g., lidocaine) is injected into the skin at the site of the procedure to achieve numbness for procedures like suturing.

Conscious Sedation

Conscious sedation is a combination of medications that allow the patient to be relaxed (midazolam) and free of pain (e.g., fentanyl) during a medical procedure (e.g., colonoscopy). This allows the patient to remain awake and aware, without feeling discomfort. The patient may or may not be able to speak or respond in this state.

General Anesthesia

General anesthesia is a medication-induced reversible unconsciousness with loss of protective reflexes. Arousal, even to painful stimuli, cannot occur. General anesthesia requires the establishment and maintenance of airway control.

Frandsen, G., & Pennington, S. (2018). *Abrams' clinical drug: Rationales for nursing practice* (11th ed.). pg. 305, 310, 952-953, 959-960. Wolters Kluwer.

Propofol is an example of an intravenous general anesthetic. The intravenous (IV) injection of propofol induces anesthesia within 40 seconds from the start of injection.

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10.11 Module Learning Activities

Open Resources for Nursing (Open RN)

Image of lightbulb **Lightbulb Moment in a circle**

Now let's apply what you have learned!

Your 82-year-old postoperative patient is hard to arouse 30 minutes after you administered IV morphine. Their BP is 102/72, respirations are 8 and shallow and SpO2 is 88% on room air. Which of the following (with health care provider orders) are priority nursing actions? Select all that apply.

- a) Administer oxygen
- b) Administer naloxone
- c) Insert a foley catheter
- d) Increase IV fluid rate
- e) Raise the head of the bed

Note: Answers to the Lightbulb Moment can be found in the “Answer Key” sections at the end of the book.

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=2465#h5p-28>

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=2465#h5p-29>

Interactive Activity

An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://wtcs.pressbooks.pub/pharmacology/?p=2465#h5p-30>

X: Glossary

Open Resources for Nursing (Open RN)

Acute Pain: Pain that usually starts suddenly and has a known cause, like an injury or surgery. It normally gets better as your body heals and lasts less than three months.

Adjuvant analgesics: Drugs with a primary indication other than pain that have analgesic properties in some painful conditions. The group includes numerous drugs in diverse classes such as gabapentin (an anticonvulsant) or amitriptyline (a tricyclic antidepressant).

Chronic pain: Pain that lasts six months or more and can be caused by a disease or condition, injury, medical treatment, inflammation, or an unknown reason.

Immune-mediated disease process: Occurs when the body's immune system attacks the central nervous system.

Misuse: The use of illegal drugs and/or the use of prescription drugs in a manner other than as directed by a doctor, such as using in greater amounts, more often, or longer than told to take a drug or using someone else's prescription.

Muscle Spasticity: Condition in which certain muscles are continuously contracted. This contraction causes stiffness or tightness of the muscles and can interfere with normal movement, speech, and gait. Spasticity is usually caused by damage to the portion of the brain or spinal cord that controls voluntary movement.

Nociceptors: Nerve endings that selectively respond to painful stimuli and send pain signals to the brain and spinal cord.

Non-pharmacologic therapy: Treatments that do not involve medications, including physical treatments (e.g., heat or cold therapy, exercise therapy, weight loss) and cognitive-behavioral treatments (e.g., distractions/diversions and cognitive behavioral therapy).

Patient controlled analgesia (PCA): To receive the opioid, the patient pushes a button on the PCA device, which releases a specific dose but also has a lockout mechanism to prevent an overdose. Included with hydromorphone or fentanyl.

Prostaglandins: Produced in nearly all cells and are part of the body's way of dealing with injury and illness. Prostaglandins act as signals to control several different processes depending on the part of the body in which they are made. Prostaglandins are made at the sites of tissue damage or infection, where they cause inflammation, pain, and fever as part of the healing process.

Vertigo: A sense of spinning dizziness. It is a symptom of a range of conditions. It can happen when

there is a problem with the inner ear, brain, or sensory nerve pathway.

XI

Answer Key

Answer keys for the critical thinking and lightbulb activities in each chapter are provided in the following sections.

1

Chapter 1

Open Resources for Nursing (Open RN)

Answer Key to Chapter 1 Critical Thinking Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 1.5a

The biotransformations that take place in the liver are performed by the liver enzymes. Therefore, if the liver is damaged, metabolism and excretion are impacted, resulting in the need for lower dosages to avoid toxicity.

Critical Thinking Activity Section 1.6a

Kidney function is important because drugs and metabolites in the bloodstream are often filtered by the kidney. In the kidney tubules, a portion of the drug undergoes reabsorption back into the bloodstream, and the remainder is excreted in the urine.

Critical Thinking Activity Section 1.7a

Before administering a Beta-1 antagonist such as atenolol, the nurse should assess the patient's apical pulse and blood pressure to confirm they are within normal range. Atenolol causes a negative inotropic effect by weakening the contraction of the heart and thus, decreases the patient's blood pressure. It also causes a negative chronotropic effect and decreases the patient's heart rate.

Critical Thinking Activities Section 1.9

1. Nursing considerations when administering pain medication include efficacy, dose-response based on the dosage selected, onset, peak, duration, and half-life of the drug. The patient has physical therapy scheduled at 0900, so the nurse should administer acetaminophen now to relieve the pain and evaluate the effectiveness in 60 minutes. The nurse should also plan on reassessing the patient's pain and potentially administering a second dose of acetaminophen just prior to the physical therapy appointment because the half-life of acetaminophen is two to three hours. Additionally, acetaminophen has a 24-hour dose restriction, so the nurse should calculate how many total milligrams the patient has received over the past 24 hours prior to administering the medication.

2. Insulin is a high-alert medication due to severe side effects that can occur if administered incorrectly. The nurse should check the patient's blood sugar reading and consider withholding the medication if the patient continues to refuse food over the next few hours to avoid causing hypoglycemia. The provider may also need to be notified of the patient's change in condition and a change in the medication order may be required.

Critical Thinking Activity Section 1.10

The normal lab values of gentamicin are 5 to 10 mcg/mL (or 10.45 to 20.90 micromol/L), so 30 mcg/mL is too high. This abnormal result could indicate the patient has renal impairment affecting metabolism and excretion of this medication. The doctor and pharmacist should be notified to adjust the next dose of gentamycin before it is administered.

Section 1.12 Lightbulb Moment

1. The nurse should select the rectal route due to the patient's difficulty swallowing to reduce the risk of aspiration.

2. The initial dose is less than the standard recommended dose based on the Mr. Johnson's age and the likelihood that his kidney functioning is decreased. Decreased kidney function affects the metabolism and excretion of gentamycin and could result in toxicities if the dose is too high.

3. Sara should wait to administer the medication until the patient's trough level is drawn. The trough level is required for the provider and the pharmacist to determine if the medication is within the range of the therapeutic window and to avoid the risk of toxicity to the patient.

4. Sam should evaluate the patient's vital signs, specifically the apical pulse and blood pressure, to be sure they are within normal range for this patient and the parameters prescribed by the provider. Atenolol has negative inotropic, chronotropic, and dromotropic effects. The negative inotropic effect weakens the contraction of the heart and lowers blood pressure. The negative chronotropic effect decreases the heart rate, and a negative dromotropic effect slows the conduction of the electrical charge in the heart. Understanding the effects of this Beta-1 antagonist medication allows Sam to anticipate expected actions of the medication and the patient's response.

5. Amiodarone is metabolized by the enzymes in the intestines to its active form. Grapefruit juice contains compounds that slow down this process and affect the levels of this medication in the blood. The nurse should educate Julia about this interaction and encourage other beverage choices in the future that do not cause this interaction.

6. The nurse anticipates that hydrocodone/acetaminophen will peak in approximately 1 hour. The patient will likely require another dose of medication for acute, severe pain that accompanies a knee replacement in approximately 4 hours.

2

Chapter 2

Open Resources for Nursing (Open RN)

Chapter 2 Critical Thinking Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 2.2a

Before administering the medications with similar mechanisms of action, the nurse should notify both providers to clarify the orders and advocate for patient safety.

Critical Thinking Activity Section 2.2b

The nurse should provide verbal education regarding when to take medication, side effects to watch for, and potential adverse effects. The patient should also be educated on any restrictions related to diet, over-the-counter medications, and herbal supplements.

Critical Thinking Activity Section 2.3a

The nurse should clarify the medication order with the provider before administration because pneumonia is not listed as an indication for levofloxacin in the Black Box Warning. Notification of the provider and the provider's response should be recorded in the patient's medical record.

Critical Thinking Activity Section 2.3b

1. The nurse should educate the patient that medications should never be shared with others. Sharing

medications is not only illegal but also dangerous. The nurse should describe the dangers to the patient, including potential drug interactions, dietary interactions, loss of consciousness, or death if inappropriate drugs or dosages are used.

2. An impaired nurse may endanger the lives of their patients or harm themselves. It is a nurse's professional and ethical responsibility to report a colleague's suspected drug use to their nurse manager or supervisor and, in some states or jurisdictions, to the board of nursing.

Critical Thinking Activities Section 2.3c

1. The five rights the nurse checks before administering any medication include right patient, right medication, right dose, right route, and right time. Checking allergies and the expiration date of the medication are also included when checking the five rights.

2. Nurses confirm patient identification prior to administering medication by asking the patient their name and date of birth, checking the patient's identification band, and by scanning bar codes on the medication and patient's armband. In long-term care settings where patients don't wear armbands and may not be able to recall their name and date of birth, the nurse may use alternative methods of identification, such as using a patient's picture in the medication record or asking another staff member to confirm the patient's identity.

3. Prior to the administration of morphine, an opioid medication, the nurse should assess the patient's pain level, level of consciousness, respiratory rate, and oxygenation status. If the patient exhibits a decreased respiratory rate, decreased oxygenation level, or an increased sedation, the medication should be withheld and appropriate interventions implemented.

4. After administering an opioid medication, the nurse should evaluate the effectiveness of the medication in treating the pain, as well as continuing to monitor respiratory rate, oxygenation level, and sedation status.

5. The nurse should teach the patient about common side effects, such as constipation and drowsiness.

6. The shift handoff report should include the location of the patient's pain, the reported pain level, pain medications administered during the shift, the time of medication administration, and the patient's response to the medication.

Critical Thinking Activity Section 2.3d

The colleague can share information about the Professional Assistance Procedure in Wisconsin that provides support to nurses who are committed to their own recovery. It is important to emphasize that the nurse jeopardizes patient safety when practicing under the influence of a substance.

Critical Thinking Activity Section 2.4

The nurse should suggest the mother obtain an oral syringe from the pharmacist to ensure accurate measurement of the medication. Errors can occur when families use spoons in their home to administer medication.

Critical Thinking Activity Section 2.5a

The nurse can use alternative sources of medication information when the patient cannot recall their home medication and it is not available in the electronic medical health records. A common intervention is to ask the patient to bring all of their medications to their appointment, including prescribed medications, over-the-counter medications, vitamins, and herbal supplements. Family members, such as a spouse or adult children, can also provide valid information with the patient's permission. After determining the patient's current medications, the nurse should print a copy of the list of medications and instruct the patient to bring it with them to all of the health care providers and update it as needed.

Critical Thinking Activity Section 2.5b

In addition to verifying the 5 rights of medication administration, the nurse should confirm the blood glucose level, insulin type, concentration, and the date the insulin vial was opened. The nurse should draw up the dose and confirm correct dosing with another RN prior to administration. The nurse should be aware of onset, peak, and duration of action and monitor for potential side effects such as hypoglycemia.

3

Chapter 3

Open Resources for Nursing (Open RN)

Critical Thinking Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 3.2a

Patient education regarding the importance of adhering to the prescribed medication regimen is vital to help prevent drug resistance. During patient education, the nurse should emphasize the need to complete the full course of medication, in the dosages and frequencies prescribed, to treat the infection and prevent the dangers of drug resistance. In addition to patient education, another solution used to prevent drug resistance in high-risk medications is called directly observed therapy (DOT). DOT is the supervised administration of medications to patients. Patients are required to visit a health-care facility

to receive their medications or a health-care professional administers medications in the patients' homes or other designated location. DOT has been implemented worldwide for the treatment of tuberculosis (TB), and research has been shown it to be effective in treating infections successfully and preventing additional drug resistance.

Critical Thinking Activity Section 3.5a

The administration of penicillin should be postponed for four hours because citrus juice can impede absorption of drugs like penicillin. The remaining doses of penicillin for the day should be rescheduled based on the time the breakfast dose was actually administered. Additionally, the patient should be educated about avoiding citrus juice while taking penicillin, and the dietary department should be notified to remove citrus juice from the meal choices.

Critical Thinking Activity Section 3.6a

The changes in the patient's renal labs demonstrate decreased renal function. The prescribing provider should be notified prior to administering additional doses of cefazolin because the medication or the dosage will likely need to be revised based on the patient's response.

Critical Thinking Activity Section 3.7a

The nurse should check the progress notes in the electronic medical record to determine if anything is documented about John's allergies and the decision to use imipenem. If nothing is documented, then the nurse should notify the prescribing provider of the patient's allergies to penicillin to confirm the appropriateness of this medication for John, document the provider's response in the medical record, and provide this information in the end-of-shift handoff report.

Critical Thinking Activity Section 3.8a

Monobactams are narrow-spectrum antibacterial medications used primarily to treat gram-negative bacteria like *Pseudomonas aeruginosa*. However, MRSA is a gram-positive bacteria, so aztreonam will not be effective in fighting this infection. The nurse should notify the prescribing provider of the results of the new culture report before administering the aztreonam.

Critical Thinking Activity Section 3.9a

The nurse should review the other medications the patient is taking. Trimethoprim-Sulfamethoxazole has many significant drug interactions, including oral diabetics. This medication may increase hypoglycemic effects requiring closer monitoring of blood sugars. Additionally, the patient's renal

status should be verified before administration of trimethoprim-sulfamethoxazole because dose adjustment may be required.

Critical Thinking Activity Section 3.10a

The nurse should immediately stop the medication and notify the provider regarding the new onset of tendon pain because this symptom indicates an adverse reaction of levofloxacin may be occurring.

Critical Thinking Activity Section 3.11a

The nurse should notify the provider of the patient's change condition because it may indicate an adverse effect of liver damage is occurring.

Critical Thinking Activity Section 3.12a

The nurse should not administer the medication until the trough levels have been drawn. The nurse should phone the lab and check on the status of the laboratory trough level.

Critical Thinking Activity Section 3.13a

The patient is under the age of six and is at risk for the adverse effect of teeth discoloration. The nurse should advocate for this patient by notifying the prescribing provider of this concern and requesting an alternate medication.

Critical Thinking Activity Section 3.14a

Oseltamivir should be administered within the first 24-48 hours of the onset of influenza symptoms. The patient may have already passed the window for maximum therapeutic effectiveness of oseltamivir. The provider should be notified regarding the onset of symptoms to clarify the prescription.

Critical Thinking Activity Section 3.15a

If there are no signs of improvement from the prescribed medication therapy, the nurse should notify the provider.

Critical Thinking Activity Section 3.16a

In order to prevent malaria, the CDC recommends patients should take antimalarial medications for four weeks after leaving the infected area. The nurse should provide additional patient education to the patient regarding this recommendation and evaluate for patient understanding.

Critical Thinking Activity Section 3.17a

Metronidazole is commonly used to treat C-diff. The medication must be given by mouth for the indication of a gastrointestinal infection like C-diff.

Critical Thinking Activity Section 3.18a

The nurse should provide education regarding the use of the medication, as well as ways to prevent re-infection. Methods to prevent reinfection include using proper handwashing, washing all fruits and vegetables, and wearing shoes in the barn or where animals and their feces are present.

Critical Thinking Activity Section 3.19a

The nurse should explain that directly observed therapy (DOT) means the administration of this medication will be supervised to ensure all doses are taken as prescribed to be sure the infection is treated properly and drug resistance does not develop. The patient will be required to visit a health-care facility to receive their medications or a health-care professional will administer the medication in the patient's home or other designated location.

Critical Thinking Activity Section 3.20a

The nurse should not administer the vancomycin until after the trough level is drawn. The nurse should call the lab to request prioritization of completing the trough level.

4

Chapter 4

Open Resources for Nursing (Open RN)

Chapter 4

Section 4.16 Lightbulb Moment

1. A potential side effect of nicotine is the activation of the sympathetic nervous system that causes an increased heart rate. Nausea and weakness are potential side effects that can indicate nicotine

overdose. The nurse should provide education to the patient regarding the avoidance of additional nicotine when using the nicotine patch. It may also be helpful to remove the patch at bedtime and reapply a new patch in the morning.

You can review additional information about nicotine administration in the [“Nicotine” section](#).

2.a. The nurse should explain to the patient that tamsulosin relaxes muscles in the bladder and prostate to improve urine flow.

2.b. The nurse should monitor for hypotension and tachycardia, especially after administering the first dose of medication. The nurse should also advise the patient to change positions slowly in order to prevent falls that can occur due to hypotension.

You can review additional information about tamsulosin in the [“Alpha-1 Antagonists” section](#).

3.a. Albuterol stimulates Beta-2 agonist receptors in the smooth muscle of bronchi and bronchioles to produce bronchodilation to ease the work of breathing.

3.b. Beta-1 receptors can also be inadvertently stimulated by albuterol and causes the side effect of tachycardia.

3.c. The nurse should educate the patient to take the medication as prescribed and avoid caffeine or other stimulants that can cause tachycardia.

You can review additional information about albuterol in the [“Beta-2 Agonists” section](#).

4.a. Propranolol is a nonselective beta-blocker and inhibits both Beta-1 and Beta-2 receptors. Inhibiting Beta-1 receptors will decrease the heart rate and reduce the force of the heart’s contraction, which will lower the patient’s blood pressure.

4.b. Before administering propranolol, the nurse should always assess the patient’s blood pressure and apical pulse. If the systolic blood pressure is less than 100 mm Hg or the apical heart rate is less than 60 beats per minute, the medication should be withheld and the provider notified unless other parameters are provided in the order.

4.c. Propranolol can inadvertently cause bronchoconstriction because it inhibits Beta-2 receptors in addition to Beta-1 receptors. Bronchoconstriction causes wheezing.

4.d. When a nurse notices new wheezing, a focused respiratory assessment should be performed including assessing the patient’s airway, respiratory rate, and oxygenation status. Depending on the urgency of the assessment findings, the nurse should also check the patient’s medical record for a history of asthma or chronic obstructive pulmonary disease (COPD) and immediately notify the provider.

You can review additional information about propranolol in the [“Beta-2 Antagonists” section](#).

5.a. Before administering metoprolol, the nurse should always assess the patient’s blood pressure and pulse.

5.b. If the systolic blood pressure is less than 100 mm Hg or the apical heart rate is less than 60 beats per minute, the medication should be withheld and the provider notified unless other parameters are provided in the order.

5.c. A new finding of edema can indicate that the adverse effect of worsening heart failure is occurring.

5.d. The nurse should assess the patient for additional signs of worsening heart failure, such as fine crackles in the lungs and recent weight gain, and notify the provider regarding this change in patient condition.

You can review additional information about metoprolol in the [“Beta-1 Antagonists” section](#).

6.a. Dobutamine is a catecholamine and it will increase heart rate, the force of heart contraction, and speed of conduction between the SA to AV nodes. These actions will help to improve cardiac output for a patient experiencing an acute episode of heart failure.

6.b. During administration of dobutamine, the nurse should continuously monitor the patient’s heart rate, blood pressure, ECG, cardiac output, and urine output. Increased urine output will demonstrate the effectiveness of the medication in perfusing the kidneys.

You can review additional information about dobutamine in the [“Alpha and Beta Receptor Agonists \(Catecholamines\)” section](#).

5

Chapter 5

Open Resources for Nursing (Open RN)

Chapter 5

Section 5.15 Lightbulb Moment

Asthma Scenario

1. The correct answer is c) Albuterol. Albuterol is a Beta-2 agonist that relaxes smooth muscle to cause bronchodilation and assist the patient with the work of breathing. It is a rapid-acting bronchodilator that is used during asthma attacks.

2.The nurse should instruct the patient to take the following steps to safely administer albuterol:

- Insert the inhaler into the spacer and shake the canister
- Breathe out all the way
- Press down on the inhaler and breathe in slowly through the mouth
- Breathe in for 10 seconds or as long as you can tolerate
- Remove the inhaler from the mouth
- Wait 30 seconds between doses

3.After administering the medication, the nurse should assess the patient’s vital signs and lung sounds, paying special attention to the respiratory rate, pulse oximetry, and heart rate for signs of improvement, as well as for potential side effects such as tachycardia.

4.The nurse should educate the patient regarding the correct method to administer albuterol, potential side effects, and the signs and symptoms of an asthma exacerbation. The nurse should ensure the patient has a written copy of their asthma action plan and verify that the patient can explain the plan to ensure proper understanding. The nurse should also explain the importance of always having albuterol on hand and to help the patient make plans for refills so as to not run out of medication.

5.To ensure correct use of the inhaler, the nurse should ask the patient to provide a return demonstration.

You can review additional information about asthma in the [“Diseases of the Respiratory System” section](#) and albuterol in the [“Beta-2 Agonist” section](#) of this chapter.

Allergy Scenario

6.The correct answer is b) Epinephrine. Epinephrine is used to rapidly treat severe allergic reactions.

You can review additional information about epinephrine and the use of Epi-Pens in the [“Alpha and Beta Receptor Agonists \(Catecholamines\)” section](#) of the “Autonomic Nervous System” chapter.

6

Chapter 6

Open Resources for Nursing (Open RN)

Chapter 6 Critical Thinking Answers

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 6.7a

1. A nurse should assess the apical pulse for a full minute before administering digoxin due to its positive inotropic action (it increases contractility, stroke volume, and, thus, cardiac output), negative chronotropic action (it decreases heart rate), and negative dromotropic action (it decreases electrical conduction of the cardiac cells). These actions can lead to bradycardia. If the patient's heart rate is less than 60 beats per minute, the nurse should notify the provider before administering digoxin unless other parameters are provided.
2. The nurse evaluates the effectiveness of digoxin based on the patient's blood pressure, apical pulse, and decreased symptoms of heart failure for which it is indicated.
3. The nurse should monitor the patient's serum potassium level because a decreased potassium level places the patient at increased risk of digoxin toxicity. Normal potassium level is 3.5 to 5.0 mEq/L, and a result less than 3.5 should be immediately reported to the provider due to the risk for sudden dysrhythmias. Serum digoxin levels should also be monitored, with a normal therapeutic range being 0.8 to 2 ng/mL.
4. The nurse should assess the patient's apical pulse and withhold the administration of digoxin. The nurse should also check for current lab results related to the serum digoxin and potassium levels. The nurse should notify the provider of the patient's change in condition that could indicate digoxin toxicity and provide information regarding the patient's apical pulse and recent digoxin and potassium levels. An order for a serum digoxin level may be received from the provider. Based on the serum digoxin level, the patient may receive a new order for digibind. Digibind is used to treat digoxin toxicity.

Critical Thinking Activity Section 6.8

The nurse should monitor the patient's blood pressure and heart rate. After 5 minutes, the pain level should be reassessed and a second dose of nitroglycerin administered if the patient's chest pain continues. If there is no improvement in chest pain, emergency services should be obtained by calling 911 or the rapid response team.

Critical Thinking Activity Section 6.9

1. Before administering a diuretic, the nurse should assess blood pressure, the daily weight trend, serum potassium and other electrolyte levels, hydration status including 24-hour input/output, and current renal function.
2. Signs of toxicity include blurred vision, nausea, and visual impairment (such as seeing green and yellow halos). A low potassium level can increase the risk of digoxin toxicity. If a patient has digoxin toxicity, severe bradycardia and even death can occur if not treated promptly. The normal range for serum potassium is 3.5-5.0 mEq/L.
3. Furosemide (Lasix) is a loop diuretic.
4. Patients receiving loop diuretics are at high risk of dehydration. Loop diuretics work in the loop of Henle where a great deal of sodium and water are either reabsorbed or eliminated by the kidney tubules.

5.The nurse should assess for the development of dehydration in patients receiving diuretics by monitoring skin and mucus membranes for dryness, blood pressure for hypotension, heart rate for tachycardia, decreased urine output, concentrated urine, and increased serum sodium levels.

6.All electrolyte levels can be decreased in patients taking loop diuretics, but potassium in particular is at high risk for depletion due to the rapid water loss that occurs.

7.Furosemide can deplete potassium levels, which then increases the risk for developing digoxin toxicity.

Critical Thinking Activity Section 6.10

1.Metoprolol is a selective Beta-1 blocker that decreases the heart rate and force of contraction to reduce blood pressure. Lisinopril is an ACE inhibitor that reduces blood pressure through vasodilation and reduces fluid retention. Verapamil is a calcium channel blocker that causes vasodilation to reduce blood pressure. Hydrochlorothiazide is a thiazide diuretic that reduces fluid retention. For this patient, all four medications may be required to maintain a blood pressure within normal range.

2.The nurse should explain that each medication works in different ways within the body to treat high blood pressure. It is vital to explain the importance of maintaining blood pressure within normal range to prevent additional complications such as a heart attack, heart failure, stroke, and kidney failure.

Critical Thinking Activity Section 6.12

1.Warfarin will not dissolve the existing clot, but it will help prevent additional clot formation.

2.When a patient is taking warfarin, the nurse should closely monitor INR and PT levels to verify they are in normal range to prevent bleeding complications. Specifically, the therapeutic range for INR is between 2.0 to 3.5 depending upon the indication.

3.Dietary instructions should be provided to maintain a consistent intake of foods high in vitamin K like leafy green vegetables. Daily changes in intake of foods that are high in vitamin K will influence the effectiveness of warfarin, as well as the patient's INR levels used to maintain the warfarin levels in therapeutic range.

4.Patient education should emphasize bleeding precautions, avoidance of NSAIDs and aspirin, the need for routine therapeutic monitoring, and when to call the provider with signs of increased bleeding or clotting.

5.The reversal agent for warfarin is vitamin K.

Chapter 7

Open Resources for Nursing (Open RN)

Chapter 7 Critical Thinking Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 7.3

Postoperative patients often require a proton pump inhibitor due to the stress response that occurs during surgery and hospitalization. Pantoprazole suppresses the secretion of hydrochloric acid and prevents the formation of a stress ulcer.

Critical Thinking Activity Section 7.4a

1. The patient may be experiencing increased heart rate as a symptom of dehydration associated with water loss from the diarrhea. Additionally, a Black Box Warning for loperamide is abnormal heart rhythm. The nurse should assess the patient's heart rate and rhythm and notify the provider.
2. The nurse can recommend providing over-the-counter probiotics, which are also found in yogurt, for the prevention of diarrhea associated with antibiotic use or to assist in decreasing the symptoms of diarrhea.

Critical Thinking Activity Section 7.4b

1. A postoperative patient has many risk factors for constipation, including side effects of anesthesia and opiates, sedentary levels of activity, and decreased fluid and food intake after surgery. In addition to administering docusate or other laxatives as needed, the nurse should educate the patient about nonpharmacological interventions to relieve constipation, such as increased fluid and fiber intake and walking.
2. Docusate softens the stool and improves the regularity of bowel movements.
3. Docusate usually works within 12-72 hours. If it is not effective in creating a bowel movement with soft stool, the patient should be instructed to notify the nurse and additional laxatives can be administered.
4. Preventative measures for constipation include increasing fluid and fiber intake, ambulating, and using the least amount of opiates needed to effectively treat the pain.

5. Bowel protocols usually include a step-wise approach to constipation. Docusate or polyethylene glycol 3350 are often used preventively, but if a bowel movement does not occur within the expected timeframe, additional laxatives such as bisacodyl or an enema may be added. A bisacodyl suppository generally produces a bowel movement within one hour whereas a mineral oil enema usually works within 15 minutes of administration.

Critical Thinking Activity Section 7.5

1. The nurse assesses for dehydration by monitoring blood pressure for hypotension, heart rate for tachycardia, urine output for decreased level, skin for tenting, and mucus membranes for dryness.
2. The dissolving tablets eliminate the risk of vomiting the medication before it is absorbed. If the patient can't tolerate the dissolving tablets, the nurse can request the provider to change the route of ondansetron to the intravenous route.
3. The nurse should plan to proactively administer medications before meals to prevent nausea. The patient can also be instructed to follow a bland diet to prevent feelings of nausea that can be stimulated by spicy food or strong flavors. Fluids should be encouraged to prevent dehydration, but if fluids increase the patient's feelings of nausea, the patient can be instructed to take frequent sips of fluid or suck on ice chips.

8

Chapter 8

Open Resources for Nursing (Open RN)

Chapter 8 Critical Thinking Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 8.5

Lorazepam is a benzodiazepine, which is a CNS depressant. The riskiest side effects associated with the use of lorazepam are respiratory depression and oversedation. Other central nervous system depressants, such as scopolamine and alcohol, can cause additive effects and should be avoided when taking lorazepam. Sedation, drowsiness, respiratory depression, hypotension, and unsteadiness may occur when taking lorazepam, so these side effects should be considered when participating in activities on the cruise.

Critical Thinking Activity Section 8.6

Patient and parent education about methylphenidate should include taking the medication in the morning and not after 4 p.m.. It is important to monitor the child's growth and weight and to provide food and snacks that the child likes if weight loss is a concern. Methylphenidate has a Black Box Warning due to its high abuse potential, and signs of misuse should be reported to the provider. The risks of drinking alcohol while taking this medication should also be discussed.

Critical Thinking Activity Section 8.7

1. A patient taking an SSRI medication like fluoxetine is at risk for developing serotonin syndrome if they have liver dysfunction or are taking other CNS medications. SSRIs are contraindicated with MAOIs due to the risk of developing serotonin syndrome. Symptoms of serotonin syndrome include confusion, elevated temperature, and rapidly changing levels of blood pressure.
2. The nurse should advise the patient of the potential for suicidal thoughts with this medication and advise her to notify her provider if she has any thoughts of self-harm.
3. Common side effects of SSRIs that the nurse should discuss with the patient include sedation, low blood pressure that can cause dizziness, suicidal thoughts, heart palpitations, sexual dysfunction, and anticholinergic side effects such as dry mouth. Patients should be advised to avoid drinking alcohol when taking an SSRI.
4. The nurse should advise the patient that it may take up to 12 weeks to reach therapeutic levels of this medication where they feel better.

Critical Thinking Activity Section 8.8

1. The nurse should explain symptoms of manic episodes include rapid speech, hyperactivity, reduced need for sleep, poor judgment, hostility, aggression, decreased impulse control, and risky behaviors. For more information about mania and bipolar disorder, review the [“Disorders of the CNS System” section](#).
2. Symptoms of lithium toxicity include diarrhea, vomiting, drowsiness, muscular weakness, and a lack of coordination. At higher lithium levels, giddiness, ataxia, blurred vision, tinnitus, and a large output of dilute urine may be seen. Lithium toxicity is prevented by regularly monitoring serum lithium levels to maintain a therapeutic range between 0.8 to 1.2 mEq/L.
3. The nurse should advise the patient that lithium reaches therapeutic range within 1 to 3 weeks.

Critical Thinking Activity Section 8.10

1. Gabapentin is classified as an anti-seizure medication, but it is also used to help relieve neuropathic pain that patients with diabetes often describe as a “burning” or “tingling” sensation in their lower extremities.

2. Gabapentin is a CNS depressant and can cause sedation, dizziness, and ataxia that increase a patient's risk for falls.

3. The nurse should plan to monitor for worsening depression, suicidal ideation, fever, rash, lymphadenopathy, dizziness, sleepiness, stumbling, and a lack of coordination. Development of any of these signs should be reported to the provider; suicidal ideation requires urgent notification.

Critical Thinking Activity Section 8.11

1. Levodopa, the metabolic precursor of dopamine, crosses the blood-brain barrier and is then converted to dopamine in the brain. Carbidopa is combined with levodopa to help prevent the breakdown of levodopa before it is able to cross the blood-brain barrier.

2. Patients taking carbidopa and levodopa have reported suddenly falling asleep without prior warning of sleepiness while engaged in activities of daily living, including operation of motor vehicles. Patients should be advised to exercise caution while driving or operating machines during treatment with carbidopa and levodopa.

3. Dyskinesia is involuntary muscle movements including tics. If a patient develops dyskinesia while taking carbidopa-levodopa, dosing adjustment or alternate drug therapy is required.

9

Chapter 9

Open Resources for Nursing (Open RN)

Chapter 9 Critical Thinking Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 9.3

1. The patient is at risk for a fracture due to a previous history of osteoporosis that weakens the bones and increases the risk for a fracture when injury occurs. Corticosteroids can cause muscle weakness that can lead to falls and fractures.

2. Alendronate, a bisphosphonates class of medication, is often used to treat osteoporosis and reduce the patient's risk of fractures. Other preventative measures can be implemented such as weight-bearing exercise and calcium/vitamin D supplementation.

3. The patient should be instructed to avoid getting up without assistance. The room should be well-lit without loose rugs that can cause tripping. If the patient uses assistive devices like a cane or walker,

these devices should be readily available.

4. The use of glucocorticoids can increase glucose levels. Although the patient has no history of diabetes, the increased blood glucose levels may require the temporary use of insulin.

5. Signs of adrenal suppression include severe fatigue, gastrointestinal upset, and a suppressed immune response that places the patient at risk for developing infections.

Critical Thinking Activity Section 9.4

1. Type 1 diabetes is an autoimmune disease affecting the beta cells of the pancreas so they do not produce insulin; synthetic insulin must be administered by injection or infusion.

Type 2 diabetes is acquired, and lifestyle factors such as poor diet and inactivity greatly increase a person's risk for developing this disease. In type 2 diabetes, the body's cells become resistant to the effects of insulin. In response, the pancreas increases its insulin secretion, but over time, the beta cells become exhausted. In many cases, type 2 diabetes can be reversed by moderate weight loss, regular physical activity, and consumption of a healthy diet. However, if blood glucose levels cannot be controlled with these measures, oral diabetic medication is implemented and eventually insulin may be required.

2. Surgery and hospitalization often stimulate a patient's stress response, which includes the release of cortisol. Cortisol increases blood glucose levels, so the patient may require insulin to control blood sugar levels while hospitalized.

3. The nurse should administer 12 units of Humalog insulin along with the scheduled 20 units of Humulin-N insulin at breakfast.

4. Metformin may be discontinued because it is contraindicated in patients with kidney disease (e.g., serum creatinine levels ≥ 1.5 mg/dL [males] or ≥ 1.4 mg/dL [females]).

5. The patient is displaying signs of hypoglycemia. A supplementary carbohydrate, such as 4 ounces of orange juice, should be administered as soon as possible. However, if the patient seems confused or unable to swallow, glucagon should be administered.

6. The patient has hypoglycemia because the peak effect of Humulin-N is about 6 hours. Because the medication is peaking between meal times, the patient's blood sugar continues to decrease. On the other hand, the onset of Humalog insulin is 15-30 minutes, with the peak effect in 1-3 hours, so the food eaten during meal time maintains a normal blood sugar as long as the meals and the insulin administration are matched.

7. The hemoglobin A1C test indicates the patient's average level of blood sugar over the past 2 to 3 months. It is also referred to as HbA1c, glycated hemoglobin test, or glycohemoglobin. Normal hemoglobin A1C is less than 5.7%. In patients with diabetes, the goal is to maintain hemoglobin A1C levels less than 7%. The patient's recent lab result of 10% indicates the need for additional diabetes medication, as well as patient education regarding diabetes management, to avoid the development of long-term complications of diabetes.

8.Lantus is a long-acting insulin that has a duration over 24 hours. It does not have a peak and should be administered once daily at the same time each day. Lantus should only be administered subcutaneously and should not be mixed with other insulin.

Critical Thinking Activity Section 9.5

The patient should be advised to take levothyroxine at the same time every morning, before eating or drinking. It should not be taken with other medications that may interfere with its absorption and should be taken at least 30 minutes before eating or 2 hours after eating. The patient should monitor for signs of hypothyroidism from too low of a dose of levothyroxine, such as constipation, weight gain, and fatigue. It is also important to watch for signs of too high of a dose of levothyroxine such as rapid or irregular heart rate.

10

Chapter 10

Open Resources for Nursing (Open RN)

Chapter 10 Critical Thinking Activities

You can review additional information regarding these answers in the corresponding section in which the Critical Thinking activities appear.

Critical Thinking Activity Section 10.6a

The patient should be advised that acetaminophen can cause acute liver damage when taken in excessive amounts or when used with alcohol. Many over-the-counter medications contain acetaminophen, so daily amounts must be monitored carefully. Recommended daily restrictions for acetaminophen include less than 4,000 mg of acetaminophen in 24 hours for an adult, less than 3200 mg for geriatric adults, and less than 2000 mg for patients with alcoholism. Fewer than three alcoholic drinks should be consumed daily while using acetaminophen.

Critical Thinking Activity Section 10.6b

The patient should be advised that aspirin has an anti-platelet effect, in addition to reducing pain, fever, and inflammation. By preventing the platelets from sticking together, clots that can cause heart attacks and strokes are prevented from forming.

Critical Thinking Activity Section 10.6c

Ibuprofen is a nonsteroidal anti-inflammatory drug (NSAID), which can cause severe and life-threatening stomach bleeding and must be taken cautiously. The patient should be advised that the risk for bleeding is higher if the patient:

- is age 60 or older
- has had stomach ulcers or bleeding problems
- takes a anticoagulant or steroid medication
- takes other drugs containing NSAIDs (such as aspirin, ibuprofen, or naproxen)
- consumes three or more alcoholic drinks every day while using this product
- takes ibuprofen in higher doses, more frequently, or for a longer time than directed

Critical Thinking Activity Section 10d

The nurse should evaluate the effectiveness of ketorolac IV in relieving the patient's pain 30 minutes after administration.

Critical Thinking Activity Section 10e

The nurse should provide the following patient education to a patient who has been prescribed celecoxib:

- It may be taken with or without food
- You can sprinkle capsules on applesauce and ingest it immediately with water
- You may experience heartburn, vomiting, or diarrhea with this medication
- Notify the provider immediately if you have abdominal pain, vomit blood or have blood in your stool, develop swelling in your hand or feet, or notice yellowing of your skin

Critical Thinking Activity Section 10.7a

Oral drops of morphine, commonly used for patients with metastatic cancer, should be effective within 1 hour of administration.

Critical Thinking Activity Section 10.7b

Naloxone immediately reverses the effects of respiratory depression and oversedations caused by opioids. After a patient receives naloxone, the nurse should continue to evaluate the patient's respiratory status at least every 15 minutes because naloxone has a shorter duration of action than many opioids, and repeated doses are usually necessary.

Critical Thinking Activity Section 10.8a

The nurse should educate the patient to take baclofen with milk or food to minimize gastric upset. Advise the patient that baclofen may cause dizziness or drowsiness, so they should change positions slowly and avoid driving and operating machines. Patients using baclofen should avoid using alcohol or taking other CNS depressants.

Critical Thinking Activity Section 10.8b

Cyclobenzaprine is a muscle relaxer and may cause drowsiness. If used with alcohol or other CNS depressants, it can impair mental or physical abilities, so the patient should be advised to not drive when taking cyclobenzaprine.

Critical Thinking Activity Section 10.8c

The patient should be advised that tizanidine can cause drowsiness and dizziness, and concurrent use with alcohol can worsen these effects. Tizanidine can damage the liver so alcohol should be avoided to prevent additional damage.

Critical Thinking Activity Section 10.11

The correct answers are a), b), and e). Based on the patient's respiratory status, the nurse should immediately raise the patient's bed and apply oxygen to rapidly increase their oxygenation level. The nurse should ask for help from a team member and/or call the rapid response team while obtaining naloxone to administer for sedation and respiratory depression. The nurse should continue to monitor the patient's respiratory status after naloxone is administered because repeated doses may be required.